DOCUMENT RESUME

ED 316 208	IR 014 203
TITLE	Information Technologies in Education. The Quest for Quality Software.
INSTITUTION	Organisation for Economic Cooperation and Development, Paris (France). Centre for Educational Research and Innovation.
PUB DATE	89
NOTE	125p.
PUB TYPE	Reports - Descriptive (141)
EDRS PRICE	MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS	*Clearinghouses; *Computer Assisted Instruction; *Computer Software Reviews; *Courseware; Higher Education; International Cooperation; *Teacher Education

ABSTRACT

In a number of Organization for Economic Cooperation and Development (OECD) member countries, a vast amount of educational software covering the major school subjects is now available. Educational authorities or independent non-profit bodies have set up clearinghouses or centers for the review and evaluation of educational software. In 1988, the Centre for Educational Research and Innovation (CERI) undertook a survey of the major centers existing in OECD countries and released the results in a report which was discussed at an international seminar of member countries' representatives and experts held in Paris in 1988. This book presents a revised version of the report and the main conclusions of the seminar. Although it is primarily focused on software review and evaluation, it is also concerned with interrelated strategies linked to educational software--in particular teacher training--for the successful introduction of information technologies in education. The book stresses the necessity for government support and international cooperation if the full educational potential of information technologies is to be realized. The first of six chapters addresses computers as teaching and learning resources and the complex issue of software, while the second discusses the quality and types of educational software. The process of software review and evaluation in each of 15 OECD countries is outlined in the third chapter, and a more detailed consideration of the nature of software review and evaluation is provided in the fourth. The fifth chapter discusses the implications of software use for teachers, and the sixth outlines the major conclusions of the International Seminar on Software Review and Evaluation. A list of acronyms used is provided. (153 references) (GL)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED316208

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)
☒ This document has been reproduced as received from the person or organization originating it.
☐ Minor changes have been made to improve reproduction quality.

- Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

INFORMATION TECHNOLOGIES IN EDUCATION

THE QUEST FOR QUALITY SOFTWARE

IR014 203

"PERMISSION TO REPRODUCE THIS MATERIAL IN MICROFICHE ONLY HAS BEEN GRANTED BY
OECD
TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

IR

Centre for Educational Research and Innovation (CERI)

INFORMATION TECHNOLOGIES IN EDUCATION

THE QUEST FOR QUALITY SOFTWARE

BEST COPY AVAILABLE

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

Pursuant to article 1 of the Convention signed in Paris on 14th December 1960, and which came into force on 30th September 1961, the Organisation for Economic Co-operation and Development (OECD) shall promote policies designed:

- to achieve the highest sustainable economic growth and employment and a rising standard of living in Member countries, while maintaining financial stability, and thus to contribute to the development of the world economy;
- to contribute to sound economic expansion in Member as well as non-member countries in the process of economic development; and
- to contribute to the expansion of world trade on a multilateral, non-discriminatory basis in accordance with international obligations.

The original Member countries of the OECD are Austria, Belgium, Canada, Denmark, France, the Federal Republic of Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The following countries became Members subsequently through accession at the dates indicated hereafter: Japan (28th April 1964), Finland (28th January 1969), Australia (7th June 1971) and New Zealand (29th May 1973).

The Socialist Federal Republic of Yugoslavia takes part in some of the work of the OECD (agreement of 28th October 1961).

The Centre for Educational Research and Innovation was created in June 1968 by the Council of the Organisation for Economic Co-operation and Development for an initial period of three years, with the help of grants from the Ford Foundation and the Royal Dutch Shell Group of Companies. Since May 1971, the Council has periodically extended the mandate, which now expires on 31st December 1991.

The main objectives of the Centre are as follows:

- *to promote and support the development of research activities in education and undertake such research activities where appropriate;*
- *to promote and support pilot experiments with a view to introducing and testing innovations in the educational system;*
- *to promote the development of co-operation between Member countries in the field of educational research and innovation.*

The Centre functions within the Organisation for Economic Co-operation and Development in accordance with the decisions of the Council of the Organisation, under the authority of the Secretary-General. It is supervised by a Governing Board composed of one national expert in its field of competence from each of the countries participating in its programme of work.

Publié en français sous le titre :
LES TECHNOLOGIES
DE L'INFORMATION ET L'EDUCATION
CHOISIR LES BONS LOGICIELS

© OECD, 1989
Application for permission to reproduce or translate
all or part of this publication should be made to:
Head of Publications Service, OECD
2, rue André-Pascal, 75775 PARIS CEDEX 16, France.

In a number of OECD countries, a vast amount of educational software covering the major school subjects is now available. For example, it is estimated that there are currently over 10 000 such programs on the market in the United States, and between 1 000 and 4 000 each in Australia, Canada, France, Italy and the United Kingdom. Since these figures are increasing all the time, a key problem for teachers is the selection of products that best suit not only their teaching requirements, but also the learning requirements of their students. This task is obviously impossible for individual teachers if they are unaided. Even if they have access to publishers' catalogues in which each item has an adequate description, they run a high risk of choosing products that are educationally inappropriate. Furthermore, teachers, after a first selection based on a catalogue, cannot "thumb through" the diskettes as they would a textbook in order to get a more precise idea of their content and methodology.

Recognising this situation, educational authorities or independent non-profit bodies such as universities have set up – or are in the process of setting up – clearinghouses or centres for the review and evaluation of educational software, sometimes giving a quality label to the best products. In the course of 1988, CERI undertook a survey of the major centres existing in OECD countries. The results were embodied in a report which also raised the main issues related to the role and functioning of these clearinghouses and to the nature of software review and evaluation. This report was discussed at an international seminar of Member countries' representatives and experts, held in Paris in October 1988.

This book presents a revised version of the report and the main conclusions of the seminar. Although it is primarily focused on software review and evaluation, it is also concerned with interrelated strategies linked to educational software – in particular teacher training – for the successful introduction of information technologies in education. As was the case with previous CERI work in this area, the book stresses the necessity for government support and international co-operation if the full educational potential of information technologies is to be realised.

This volume has been prepared by John A. Winship, Director of the Non-Government Schools Computing Centre, Curtin University of Technology, Western Australia, working in close co-operation with Pierre Duguet of the CERI Secretariat.

Also available

NEW TECHNOLOGIES IN THE 1990s: A Socio-economic Strategy (1988)
(81 88 07 1) ISBN 92-64-13180-9 130 pages £11.00 US$19.00 FF90.00 DM35.00

INFORMATION TECHNOLOGIES AND BASIC LEARNING. Reading, Writing, Science and Mathematics (1987)
(96 87 05 1) ISBN 92-64-13025-X 270 pages £15.00 US$32.00 FF150.00 DM65.00

NEW INFORMATION TECHNOLOGIES: A Challenge for Education (1986)
(96 86 01 1) ISBN 92-64-12824-7 122 pages £8.00 US$16.00 FF80.00 DM35.00

ICCP "Information, Computer and Communications Policy" Series
No. 9 – SOFTWARE: An Emerging Industry (1985)
(93 85 04 1) ISBN 92-64-12755-0 204 pages £12.00 US$24.00 FF120.00 DM53.00

Prices charged at the OECD Bookshop.

THE OECD CATALOGUE OF PUBLICATIONS and supplements will be sent free of charge on request addressed either to OECD Publications Service, 2, rue André-Pascal, 75775 PARIS CEDEX 16, or to the OECD Distributor in your country.

TABLE OF CONTENTS

Introduction 7

Chapter 1. **COMPUTERS AS TEACHING AND LEARNING RESOURCES: THE COMPLEX ISSUE OF SOFTWARE** 11

- The Impact of Computers on Education 11
- Factors inhibiting the Use of Computers across the Curriculum: the Key Issue of Software 19

Chapter 2. **EDUCATIONAL SOFTWARE: THE CONCEPT OF QUALITY AND THE TYPES OF SOFTWARE** 31

- Quality in Educational Software 31
- The Quality and Types of Educational Software 34
- Trends in Educational Software 42

Chapter 3. **SOFTWARE REVIEW AND EVALUATION IN OECD COUNTRIES** 45

- Australia 46
- Belgium 48
- Canada 49
- France 52
- Germany 55
- Italy 55
- Japan 56
- The Netherlands 57
- New Zealand 57
- Sweden 57
- The United Kingdom: 58
  - England, Wales and Northern Ireland 58
  - Scotland 60
- The United States 61

- Software Review: Diversity and Common Features 68
  - Software Clearinghouses 68
  - Mechanisms for the dissemination of information 70

Chapter 4. THE NATURE OF SOFTWARE REVIEW AND EVALUATION 75

- Software Review or Software Evaluation? 75
- The Value and Validity of Software Reviews 77
- The Review Process 79
- Criteria used in reviewing Software 81
- The Reviewers 87
- Software Evaluation 88
- The Need for Evaluative Studies and Research 91

Chapter 5. THE TEACHER AND THE USE OF EDUCATIONAL SOFTWARE 93

- The Teacher's Point of View 93
- Teacher Education and Training 94
- Teacher Support Services 99

Chapter 6. MAIN CONCLUSIONS OF THE INTERNATIONAL SEMINAR ON SOFTWARE REVIEW AND EVALUATION 105

Epilogue 113

List of acronyms 117

Bibliography 119

INTRODUCTION

The new information technologies have improved and altered the teaching and learning processes in many ways, and it is often claimed that the potential of the microcomputer for education is unprecedented in content as well as scale. However, previous studies conducted by the OECD, such as *New Information Technologies: A Challenge for Education* (1986) and *Information Technologies and Basic Learning* (1987), have shown that to date this potential has not been realised in most schools in Member countries, even in those where microcomputers are now relatively commonplace.

The introduction of computers into schools has changed not only the manner of teaching: it has also brought about changes in *what* is taught. Developments in Australia can be regarded as typical. To quote from the evaluation study of the National Computer Education Program:

> "The advent of schools computing has added new words to the lexicon of school subjects, not only by adding the contents of whole new 'subjects' like 'computer awareness', 'computer literacy' and 'computer science' to the school curriculum. It has also changed existing subjects. A few examples suffice to show how: commerce now includes word processing and more generic notions of 'keyboard skills'; maths and science may include programming skills (from relatively humble uses of 'turtle graphics' through to very sophisticated modelling and simulation exercises); geography, history and social science use databases and extend their use of quantitative methods; English, as well as language education in a variety of subjects across the curriculum, may include the use of word processing as a key element of learning to write, creative writing and 'classroom publishing' " (Kemmis, 1987).

Examples can also be given of ways in which the use of the computer can bring about changes in how students learn and teachers teach. A number of studies, for example, have commented that children feel positive about activities using the computer and that they feel a sense of independence when working at the computer and satisfaction in their ability to control the technology. Observers report a higher level of motivation in children working at computers and increased and enthusiastic collaboration between students involved in co-operative activities such as shared writing and group decision-making at the computer. Students learn more using computers. They also learn more quickly. Particular applications have had notable results. Studies in the use of word processing, for example, have shown that even formerly reticent students often express ideas and opinions with more enthusiasm when using a word processor and that *process writing* becomes a realistic practicality for children when they are released from the drudgery of rewriting their work by hand. The use of interactive simulations, LOGO, graphics systems and music design systems allows students to explore other microworlds.

Although the information technologies have had a notable impact on the curriculum, teaching and learning, as discussed in Chapter 1, the overall impact on education has been limited to date. Evaluative studies conducted in Australia (1985 and 1988), England (1987), France (1986), Norway (1987), Scotland (1987) and the United States (1985 and 1988) have shown that computers are not yet major tools in the classroom.

Hence, as Ely (1987) says:

> "We are left with the paradox of a society in which the information level outside the classroom is much higher than inside; where technology has become a way of life in commerce, government, health care, and the military, but not in the schools. When it does find its way into education settings, technology is additive and not integrative, an artifact of our times trying to find a place for itself in an established institution that has been noted for its resistance to innovation".

Why has the potential of the New Information Technologies not been realised? An easy answer would be that the current generation of microcomputers being used in schools, and the technology itself, are not adequate for the tasks to which they are being put, but this is not the case, and it is clear that education is not utilising to the full what is currently available. As Gwyn (1986) has said:

> "There is a very real sense in which it would matter relatively little if technological advance were to halt over night (it is of course unthinkable that it should) since there is sufficient implicit in existing technology to keep educationalists occupied for the rest of the century".

There does not appear to be one simple answer but rather a number of factors which occur in various combinations and inhibit the use of computers across the curriculum in schools. These factors are discussed in some detail in Chapter 1. They include the lack of adequate hardware facilities in schools, the lack of quality software which meets the curriculum needs of teachers, the lack of adequate support facilities for teachers to find out about software and assess its relevance to meet their needs, the lack of appropriate training for teachers and the more general problem of how education systems can be made more responsive to innovation.

Among these factors, identifying and selecting high quality software which can be integrated into the curriculum remain a central issue. Central to that issue is the question of the quality of software. In some countries there is now a considerable amount of educational software available. In the United States, for example, the quality of software is improving and there are now over 10 000 stand-alone packages available as well as an increasing number of *integrated learning systems*. However, in spite of progress, the range of quality software in many countries is still limited.

The concept of quality in educational software, of what makes a piece of software an effective teaching or learning resource, is discussed in Chapter 2. It is the result of the interaction of a number of variables, including the subject matter being taught and the curriculum, teaching and the teacher, learning and the learner, the technology itself and the type and design of the software being used, all of which are subject to extremely rapid change and development. At the international level these factors are compounded by national and cultural differences which can cause a piece of software considered excellent in one country to be judged of little value in another. The types of educational software are also described briefly in Chapter 2.

In a number of the OECD countries considerable effort has been spent over the past few years in developing agencies for the review and evaluation of software in order to help teachers identify quality software. When searching for software, teachers will wish to be provided with the answers to questions such as the following: What software capable of meeting my curriculum requirements has been produced, by whom and how much will it cost? For which microcomputers is it available? Is any special hardware or software needed for its use? What are its contents? What is it intended to do? Who is the target audience? Where can I preview it? Where can I obtain a copy? What do others think of it? How up-to-date is this information? Are there case studies, curriculum guides or descriptions of classroom implementations of the software that are relevant to my needs? Activities in OECD countries, including mechanisms for the distribution of information about software, are described in Chapter 3.

This leads on to a discussion in Chapter 4 of the nature of software review and evaluation. In the context of this study distinctions are made between software description, software review and software evaluation. The first, *software description*, is used for an objective and informative description of a piece of software. The second, *software review*, is used for a critical appraisal by one or more persons of the educational value of a software package as a teaching or learning tool. The third, *software evaluation*, is used for a judgement about the value and usefulness of a piece of software, involving an in-depth analysis and observation of the use of the software by means of quantitative and qualitative measurements and methodologies. This chapter discusses these concepts and related issues such as the value and validity of software reviews, the review process, the criteria used in reviewing, the reviewers, software evaluation and the need for evaluative studies and research on the use of computers across the curriculum, and related issues.

Chapter 5 discusses the training and support needed by teachers using software in the curriculum. The training given to all teachers, whether at the pre-service or the in-service stage, should include training in assessing and selecting software. Such training should be part of the in-depth training in the pedagogical uses of the information technologies which is needed by all teachers. The chapter also discusses the support needed by teachers in their use of software across the curriculum at the school, district, state, or regional and national levels.

In Chapter 6 a report is given of the International Seminar held in October 1988 at OECD Headquarters. The Seminar participants discussed the major issues raised in this study and came to the following main conclusions:

1. We cannot afford not to provide teachers with information about available teaching and learning software;
2. Although opinions would appear to differ, there is in fact a broad degree of agreement on the feasibility and value of the educational review and evaluation of educational software;
3. There is a continued need for agencies and mechanisms to provide teachers with information about the quality of software;
4. Teachers need training in the selection of software as well as prior training in the pedagogical uses of computers;
5. There are opportunities for international co-operation in the review and evaluation of software and in access to educational software;
6. The quality of software depends on a number of interrelated, evolving variables: the quality of software and the review and evaluation of software should therefore be considered in the light of past and future developments.

Chapter 1

COMPUTERS AS TEACHING AND LEARNING RESOURCES: THE COMPLEX ISSUE OF SOFTWARE

THE IMPACT OF COMPUTERS ON EDUCATION

Although the use of computers was introduced into the educational systems of some OECD countries in the late 1960s and early 1970s, the major developments in the use of computers in schools have taken place in the 1980s since the advent of the microcomputer. In many countries there have been development programmes co-ordinated by the education authorities, in some cases at the state or provincial level and in others at the national level. Developments and the associated programmes have been concerned mainly with three complementary aspects of the use of computers in schools, namely:

- Computers and information technology as subjects of study in their own right. This aspect has led to the development of various courses in computer science and information technology, particularly at the vocational and upper secondary level;
- Computers and information technology as an integral part of culture and society which all students should experience and become confident in using during their years of schooling. This aspect has led to the development of courses such as "computer awareness" or "computer literacy", which aim to give students an understanding of the application of the information technologies and their social implications and are often compulsory for all students at the lower secondary level;
- Computers and information technology as teaching and learning resources. This aspect has led to the integration of the information technologies into the curriculum.

Countries have devoted considerable resources to programmes which have placed different emphases on these three aspects. Previous OECD studies have shown that at the beginning of the 1980s some countries – for example, Austria, Belgium, Denmark, Finland, Germany, Greece, Ireland, Japan or Luxembourg – developed policies which emphasized primarily the introduction of computer science into vocational and upper secondary education. These *restricted* policies differed from those of other countries – for example, France, the United Kingdom and the provinces of Ontario and Quebec in Canada – which developed *comprehensive* policies, aimed not only at teaching computer science but at teaching computer literacy at all levels of education and at integrating the use of the computer in the curriculum in order to improve the teaching and learning processes.

During the 1980s the *restricted policy* group has moved towards the *comprehensive policy* group by adopting the objective of computer literacy at all levels of education. They have, however, still focused their resources on teaching about computers rather than on the use of computers as an educational tool.

The general trend in countries now, however, which was confirmed at the October 1988 Seminar, is for countries to move towards the *comprehensive approach*. For example, Australia and the United States, which started from a computer awareness or computer literacy approach, and Japan, the Netherlands and Norway, which started from a computer science approach in vocational education, are now taking a comprehensive approach. Countries which started a programme of action in the mid-80s, such as Italy, Portugal or Spain, have clearly stated that their objectives are to teach about computers and to learn with computers.

This difference between the restricted and the comprehensive policies in OECD countries has also led to conceptual differences and differences in usage between countries with regard to the perceived relationship of software to the curriculum, teaching and learning. The expression *computers across the curriculum* consequently has different meanings in different countries. In some countries where the policy is to concentrate on education in the information technologies, the use of commercial software packages which are tools in specific subject or vocational applications is seen as an aspect of computers across the curriculum. So, for example, the use of Computer-Aided Design (CAD) packages within engineering and technical drawing is seen as using computers across the curriculum. Similarly, for example, learning to program in order to use the computer as a problem-solving instrument is seen by some as using the computer across the curriculum. In the majority of countries, however, *using the computer across the curriculum* means using the computer in some way as a resource which aids the teaching or learning process.

A number of terms are used to refer to the use of the computer as a resource in the teaching or learning process. The most commonly used are Computer-Assisted Learning (CAL), particularly in the United Kingdom, Computer-Based Learning (CBL) and Computer-Assisted Instruction (CAI) in the United States, and *Enseignement Assisté par Ordinateur* (EAO) in France. They refer with various shades of meaning to the computer as a tutor teaching new concepts, as an exerciser giving the learner individualised practice in concepts or skills, or as the means of providing opportunities to acquire new knowledge and skills through a range of uses such as simulations, the use of databases, problem-solving, data analysis or other techniques made possible by the computer.

Many authors consider the range of uses of the computer to be virtually limitless. Papert (1980), for example, describes the computer as the Proteus of machines whose essence is its universality and its power to simulate. "Because it can take on a thousand forms and serve a thousand functions, it can appeal to a thousand tastes".

Robinson (1982) describes some of these forms as follows:

> "What is the total potential of computers? It is limited only by our imagination. It's like giving an artist a palette that has an infinite number of colours, some of them even invisible to the naked eye, like ultraviolet or x-rays. It's like putting into the hands of a sculptor a chisel of infinite sharpness to be used against a clay of endless malleability that makes it possible to model the growth of trees, the flow of water, the distillation of petroleum, the structure of the earth's crust, the growth of cancer cells, or even the movements of chess pieces. It's like giving to a composer a set of musical notes and harmonics and chords, some of which have never been played before. It's like giving a poet an alphabet that is not limited to our letters and ideograms, that is virtually infinite in scope. It is a tool for the realisation of ideas and it carries with it a challenge for all of us".

Although the results of research give an incomplete and impressionistic picture, by and large they support the view that the information technologies have considerable potential to enhance education. It is clear, however, that the potential is not being realised in schools in most countries. It is appropriate therefore to consider the impact that the information technologies have had on education, in particular the curriculum, teaching and learning, and, in the context of this study, to examine the reasons why that potential is not being realised.

The Impact on the Curriculum

The introduction of the information technologies into the curriculum has brought about a number of changes in the curriculum itself.

The most conspicuous change has been in the creation of new technology-related subjects such as computer awareness and computer science, which aim to prepare students for the increasingly technological world they will face on leaving school. Other subjects, particularly those of a vocational nature such as business studies, engineering and technical drawing, have been radically changed through the introduction of computers into schools.

There have also been changes in the cognitive content of traditional subjects. When computers are used, a shift away from mechanical activities towards higher-order skills is evident in a number of subjects. Dramatic changes in mathematics teaching were reported, for example, at an International Seminar on Microcomputers and Secondary Teaching organised jointly by OECD and the Scottish Education Department (1988). Delegates noted changes in the nature of mathematics as it is practised and applied by professional mathematicians. It was observed that the availability of tools such as pocket calculators and exploratory mathematical environments means that many of the customary ways of solving mathematical problems have become irrelevant and inefficient. The use of microcomputers provokes profound questioning of what it means to know mathematics. If *getting the answer* is becoming so easy that anyone can do it, then teachers need to develop more accurate ways of finding out whether or not the student has grasped the *concept*.

The same shift towards higher-order skills is also evident in the use of word processing to support process writing.

> "If pupils write compositions only on assigned topics, and instruction is based on the teacher's corrections and notes, a word processing program is beneficial only with regard to surface features, such as grammatical correctness or spelling. If, on the other hand, teaching emphasizes the writing process and includes brainstorming, planning, searching for data and revising the text, as well as feedback from the teacher and classmates, information technologies provide possibilities for quite different kinds of work" (Bruce, 1987).

New activities and topics which can only be treated because of the advent of the computer are being included in existing subjects. A number of examples can be given. In Scotland a macro-economic simulation model of the British economy is used with senior secondary students both for teaching and assessment. In Norway a weaving program is used for pattern composition and texture analysis, thus removing much of the tedium of composing complex patterns by hand. The combination of the Musical Instrument Digital Interface (MIDI), an electronic keyboard and a microcomputer provides students with the facility of composing and practising music on their own. The availability of desk-top publishing facilities in schools allows students to develop products such as monographs, magazines and newsletters of a professional quality.

Computers in schools have made possible an increased use of exploration and discovery methods. Software permits the creation of so-called microworlds of geometry, music and graphics. For example, students can invent geometry for themselves, make geometric constructions and explore relationships between geometric shapes. Simulation packages allow the modeling of other environments and experiments and give students types of activities which were not possible before.

Research has also shown that the computer is a potentially powerful tool for meeting the needs of children with special learning needs. It has consequently been described by some as *the freedom machine*, opening the door to educational pathways previously inaccessible to handicapped or learning-disabled students. For the physically handicapped, adaptive devices can make communication itself possible.

Although to date the information technology tool most prevalently used in teaching or learning is the microcomputer, other information technologies such as telecommunications and television (video) are also being used. For example, a growing number of schools, especially those in remote and isolated areas, use telecommunications facilities such as two-way video and audio as normal means of conducting classes and of communication between teachers and students. In many schools the use of the videocassette recorder is now a commonplace and everyday occurrence. The newer transmission technologies such as satellite communication, fibre optics and facsimile transmission facilitate the delivery of video, audio and computer communications.

It is the convergence of the various information technologies, however, which has the greatest potential for the development of new teaching and learning tools and the improvement of education. Examples of convergence include the marriage of video and computer technologies in the computer-controlled laser videodisc and the combination of computers and the communication technologies, which provide the means for teachers and students to share information and experiences across cities, countries and continents.

The Impact on Teaching

In its evaluation of the use of the information technologies, the Office of Technology Assessment of the Congress of the United States (OTA, 1988) found that there are as many ways of using computers in the classroom as there are varying teaching styles and that asking how teachers use computers and what effects computers have on teaching are questions almost as broad as *How do teachers use books and how do books affect teaching?* Just as there is no one best use of technology, there is no one best way of teaching with technology.

Teachers' use of computers depends on their instructional goals, teaching approach, training, the software and hardware available to them, and the instructional setting in which they use them. Some teachers use computer laboratories, whilst others have computers in their classroom. Some use the computer to teach lessons to the whole class; others emphasize individual instruction. Some use the computer only within the limits of their standard curriculum; others use it to create a whole new curriculum. The way teachers use groups of computers in laboratories is very different from the way they use one or two in the classroom. A single computer in a classroom can be used by the teacher in various ways at various times: sometimes as a learning station for individual students, sometimes for interactive demonstrations led by the teacher for the whole class and at other times for collaborative problem-solving by a small group of students. Use varies from subject to subject. Use in social studies is different from that for science laboratory work; drill and practice for review of basic skills is very different from students programming a computer to make machines move.

> "One of the most significant impacts of the use of computers in the classroom is change in teaching style. Teachers can go beyond the traditional information delivery mode whereby they are presenters of ready-made knowledge and become facilitators of students' learning. With computers, students can work on problems individually or in small groups while the teacher acts more like a coach circulating among them and giving assistance. Some teachers find that they are able to observe more of the learning process when watching students interact with computer-based materials. Some teachers welcome the opportunity to learn alongside their students. For many, this is a significant change from how they were taught to teach. It can be both exhilarating and intimidating. ... Teachers who use the computer as a medium that students can manipulate individually or in small groups find their students become more actively engaged in learning and thinking than during traditional lecture-oriented lessons. Such teachers use the computers to give students more responsibility for their own learning. Students can work at their own speed and can figure out more for themselves. Some students who do not respond well to lessons based around a lecture format deal more positively with the interactive, visual medium of the computer" (OTA, 1988).

The use of computers can also ease some aspects of classroom management, as reported by Japanese research:

> "In addition to direct instructional use, teachers can also use computers in editing lesson plans and curricula or in preparing instructional materials ... (they can) ... develop a system for storing, maintaining and retrieving necessary information on instructional methods, materials, aids and school activities, efficiently process and analyse student academic and health records, more fully grasp each student's rate of development, more accurately evaluate each individual's abilities and aptitudes" (Inoue *et al.*, 1987).

Teachers also frequently find changes in the attitude of students using computers. For example, when students are engrossed in their work on the computer, teachers frequently find discipline problems evaporate, students are more enthusiastic about school and their work, and absenteeism decreases.

The Impact on Learning – What do the Cognitive Sciences have to say?

Although there is plentiful evidence of the impact of the information technologies on the curriculum and teaching and of ways in which they can be improved, their impact on learning is as yet largely unknown. There has been little research into how students learn with computers, what they learn when they interact with computer-based materials or how their learning could be improved by the use of the information technologies. This leads to three concerns. The first is that much of the software currently available may be based on models of learning which are outdated and outmoded by the standards of the modern cognitive sciences.

The second concern is that software is based on models of learning which are analogies of the storage and processing operations of computers. Such software may fit the computer but not the human learners. As Entwistle (1987b) has said:

> "To look first at microcomputers would implicitly suggest that we accept the machines as the 'given' and then decide how to adapt teaching to their current mode of operations. Rather we need to develop a new pedagogy from the most up-to-date knowledge about human learning, and then see what contributions microcomputers can make. That strategy will allow us to look for ways of altering computer design to support human learning,

> rather than trying to accommodate human learning to the current state of computer technology".

A third concern has been noted by Scardamalia and her colleagues (1987):

> " ... there is a potential conflict between the principles that inform most software development and those that ought to guide the development of educational software. In most software design it is desirable to make the software as intelligent as possible and to demand as little intelligence as possible from the user. Educational applications on the other hand, should be aimed at developing the intelligence of the user. Educationally irrelevant burdens should be minimised, but not in ways that deprive students of occasions to develop the planning, monitoring, goal-setting, problem-solving and other higher-order abilities that are important objectives of education".

It is appropriate therefore to look briefly at recent educational research to see what bearing it has on computer-based learning. It should be noted that although modern research has provided new concepts and new insights into older concepts, the basic principles of learning, such as the importance of repetition in skill or rote learning, of appropriate reward to maintain motivation, and of adequate and prompt feedback to correct errors of fact or interpretation, still apply. Following are some of the concepts emphasized by cognitive science which appear to have a bearing on the use of the computer in education.

It is to be noted that the following description of recent educational research draws heavily on Entwistle's analysis presented at a joint OECD and Scottish Education Department Seminar on Microcomputers and Secondary Teaching held in 1987.

Learning is a constructive process

The contribution of the cognitive sciences to education has been to provide a clearer understanding of the active nature of thinking and learning. Some earlier views characterised learning as a process in which responses were tied reflexively to categories of stimulation, or symbols were passively accepted and stored. Although not novel, a more recent view is that people construct their own knowledge through linking concepts to idiosyncratic experience. The implication for the use of computers in education is that they must somehow be used not just to present information or to drill the student's knowledge of it but to activate and encourage the student's own process of constructing knowledge.

> "Much of current education, and especially of educational technology, aims either at drill or at the storage of knowledge in students' minds, rather than at what knowledge students might construct in response to interactions with a computer system. If we really believe that students learn by constructing their own knowledge, then the specific words we spray on them in lectures or show them on book pages have only a temporary importance. ... The implication of this is that the technological artifacts for the classroom must be examined in sufficient depth to determine what learning activities they induce, not what words they display" (Lesgold, 1987).

Approaches to learning

According to Entwistle an important landmark in research into learning is the work of Marton who found that different approaches to learning account for the different levels of understanding attained by students. He found that they adopted either a deep or a surface approach to learning.

The deep approach involves an intention to reach a personal understanding of the material presented; this requires a lively interaction with the content, relating it to previous knowledge and experience; it also demands an examination of the evidence and an evaluation of the logical steps by which conclusions are reached. In contrast, the surface approach involves an intention merely to satisfy task or course requirements, which are seen as external impositions largely remote from personal interests; it may be active but it relies on identifying the elements within the task most likely to be assessed and then memorising those details.

The distinction between deep and surface approaches to learning has important implications for instruction. First, since the long-term goal in most school subjects is understanding, instruction, wherever appropriate and possible, should direct the learner towards the development of personal understanding, even though some rote learning may be necessary in the early stages of a subject or for a particular purpose. Second, the factors influencing approaches to learning need to be examined and allowed for in any instruction. According to Entwistle (1987a), there is now a substantial body of evidence about such influences from which implications about the use of microcomputers might be derived:

> "Anxiety, instrumental motivation, time pressure, dependency and, above all, narrowly focussed assessment procedures push students into surface approaches. It is more difficult to direct students into deep approaches, but a context which allows freedom of choice, emphasizes relevance and interest, and explicitly rewards the personal reconstruction of meaning will allow those who have the prerequisite knowledge and skills to reach deeper levels of understanding".

Metacognitive awareness

Other research has emphasized the importance of developing an awareness of one's own cognitive strategies. It has shown that in order to develop personal understanding, the learner has first to be aware of what is demanded in a learning task; he then has to decide on appropriate strategies to use existing knowledge and skills in the right sequence and finally he has to monitor both process and outcome (Nisbet and Shucksmith, 1986; Selmes, 1987). This process of directing skills more consciously towards task requirements and monitoring their effectiveness is known as metacognitive awareness. To encourage this awareness, instruction must emphasize the purpose as well as the specific objectives of a lesson so that learners have a sense of direction in their learning (Brophy, 1987).

Styles of learning

Pask (1976) has found that even when students are required to reach understanding, they still show distinct preferences in how they set about it. He described these differences as learning styles and distinguished the holistic and the serialist styles. In the holistic style the student first tries to make sense of the learning task within a broad context by forming an overview; having done this, he then begins the task, making wide use of illustrations, examples, analogies and anecdotes as he builds up an understanding which is deeply rooted in personal experiences and beliefs. Students preferring a serialist style, on the other hand, begin with a narrow focus, concentrating on details and logical connections and look at the broader context only towards the end of the task.

Extreme holists are impulsive in their use of evidence, often tending to generalise too readily and jump to conclusions. Extreme serialists are often too cautious, failing to see important relationships or useful analogies, thus leaving their understanding impoverished. Most learners fall between the two extremes, using both of the styles of learning, although it would appear that preferences for relying more on one or the other are relatively consistent, being rooted in the individual's personality (Entwistle and Ramsden, 1983).

These differences in learning styles have implications for computer-based learning: students will not adapt readily to materials presented in ways that are incompatible with their developed style of learning. The individualising of instruction will therefore need to cater not only for variable pacing and complexity but also for alternative forms of presentation, depending on the style of learning of the user.

Diagnostic feedback

The importance of feedback in any use of the computer in education is evident, and the provision of such feedback for factual accuracies and inaccuracies is normally relatively easy and straightforward. But when we take into account the student's approach to learning, metacognitive awareness and style of learning, providing appropriate feedback is a different matter: a much more sophisticated level of feedback is needed which is capable of diagnosing what the student's problems are and where he/she is going wrong.

Although some American research has stimulated the use of concept maps as a way of helping students and teachers to explore together their conceptual understanding or misunderstanding, precise feedback is still a long way off in many subject areas. As Entwistle (1987a) says:

> " ... there has to be accurate diagnostic assessment which can inform teachers and pupils alike about weaknesses, together with procedures and materials specifically designed to help pupils overcome those weaknesses".

The Overall Impact on Education

Despite the wide range of possibilities which the information technologies offer and the impact they have already had, the use of microcomputers across the curriculum remains relatively low in most OECD countries, as a number of studies have shown.

A Department of Education and Science survey, for example, showed that in 1985/86 in England and Wales microcomputers were used most frequently in computer studies and mathematics departments in schools. An analysis of the Second National Survey of Instructional Uses of School Computers commissioned by the United States Department of Education in 1985 (Becker, 1987) found that computers were not yet major tools in mathematics, science or social studies although their use in science classes was not unusual; the number of high school students studying programming had increased; word processing had become a larger component of high school business education programmes but it had not become the routine means by which students wrote their English compositions. In Scotland, the HM Inspectors of Schools concluded as a result of their survey of 1985-86:

> "Examples of good practice in the use of microcomputers were observed in all subjects and in all parts of the country; it would be wrong, however, to infer that such examples are as yet to be found in the majority of schools" (Scottish Education Department, 1987).

The evaluative study on the Australian National Computer Education Program of 1984-86, for example, had this to say about schools computing in Australia:

> "Justified by the presumed imperative of the 'technological society', the computer is edging its way towards centre stage in some schools and classrooms. But the assimilation is far from complete, despite the observation that, in some places, computers in schools have become so commonplace that they have lost their novelty. At this stage in the development of schools computing in Australia, most schools have a long way to go before they will have sampled even a small proportion of the existing possibilities of educational computing, let alone arrived at a sound educational computing policy and practice" (Bigum *et al.*, 1987).

The OTA reports that in the United States only half of the country's teachers say that they have used computers in instruction and that few teachers have found ways to exploit their enormous potential. OTA (1988) concludes that although many instances of exemplary use of computers in school can be given:

> " ... this remarkable achievement in the schools pales in comparison with the rate and magnitude of entry into the age of information experienced by business, the military, higher education and medicine. ... in general, classrooms today resemble their ancestors of 50 and 100 years ago much more closely than do today's assembly plants, scientific laboratories and operating rooms. A number of information technologists point out that if business organisations today evolved at the same rate as the schools, they would still be using quill pens instead of electronic word processors".

FACTORS INHIBITING THE USE OF COMPUTERS ACROSS THE CURRICULUM: THE KEY ISSUE OF SOFTWARE

An analysis of reports from the various OECD countries makes it possible to identify many of the factors inhibiting the more widespread use of computers across the curriculum. They include the lack of hardware and especially the lack of quality software, the lack of access to reliable information about software and the related lack of adequate training and support for teachers.

Factors related to Hardware

The lack of hardware in schools

Despite relatively large investments made by education systems, institutions and other interested parties, and the decreasing unit cost of microcomputers, many schools have insufficient hardware. This has affected not only student access to hardware but also the supply and type of educational software which is available.

According to an OECD survey in 1987 of the secondary level of education, a number of countries including Australia, France, England and Wales, Scotland and the United States claim that all general secondary schools are equipped on average with 9 to 20 microcomputers. These figures become more informative when they are related to the size of the school and the average ratio of computers to pupils for each country is calculated. The following interesting ratios appear: Australia, 1:49; Austria, 1:30; France, 1:38; England and Wales, 1:32; Scotland, 1:30; and the United States, 1:27. This means that on average each pupil has between five and seven minutes of direct computer contact per day, or 25 to 60 minutes per week. In practice, the effective contact may be twice this, since many computer activities involve groups of two pupils working with one machine.

There is very little reliable data on what would constitute an ideal ratio of computers to students. The OECD estimates that the current stock of equipment would need to be roughly doubled if countries are to reach an adequate ratio, which it reckons to be one microcomputer per ten pupils, i.e. 30 minutes per pupil per day or two and a half hours per week.

The problem is exacerbated by the fact that the existing computer and human resources in institutions have been largely monopolised by subjects such as computer awareness and computer science, sometimes to the exclusion of use across the curriculum. This is especially so at the secondary level of education. The computers have largely disappeared into laboratories dedicated to the use of these new subjects, and very often teachers of non-computing subjects have in fact been denied access or given only very limited access to the computers.

OECD work has shown the following trends for the future: At the primary and secondary levels of education most hardware resources will be devoted to the use of the computer in the curriculum; to a greater and greater extent, these resources will be located in the classrooms; their use will be directed towards basic knowledge in reading, writing, language arts, sciences and mathematics. The existing pilot experiments in a number of countries at these education levels confirm this trend. It should be noted that in such cases not only do pupils have access to the hardware for about five hours a week (i.e. a computer-student ratio of 1 to 5) but that the microcomputers they use are powerful ones, generally 16- and 32-bit personal computers with a videodisk.

Effects of the lack of hardware on software

The lack of sufficient hardware in schools has had a number of effects on educational software, some good, some bad.

Because of the lack of hardware available in schools as teaching and learning resources, the market for educational software has been relatively small. As a result few commercial publishers have considered it worth their while to invest in large-scale software developments or publications. The development of educational software has consequently remained a cottage industry with most educational software being written by teachers or academics in their spare time without the resources or expertise to market their software. This has led inevitably to the random production of a patchwork of small pieces of stand-alone software packages designed for particular topics or aspects of the curriculum, rather than a range of software designed to meet the whole of the existing curriculum.

Even in countries which are relatively well developed in the use of the computer across the curriculum the availability of only one microcomputer per classroom is not uncommon. This has forced software developers to develop software which can be used with the whole class or with groups within the class and has forced teachers to look for such software and devise and develop new classroom management techniques in order to integrate the use of the computer. In these circumstances the availability of software which requires individual use by students in a one-on-one interaction with a computer is totally irrelevant, no matter how excellent its quality.

Often, the lack of funds for hardware also appears to force schools and education authorities to base their choice of hardware not on the educational aims they hope to achieve with the computers but on the number of computers they can buy with the limited funds available for this use. When buying, the criterion often appears to be the number of keyboards that can be bought, not what is going to be done with them. In such a situation schools will often opt for the less powerful and older types of hardware simply because they are cheaper, without realising that much of the software coming with such computers is also older and less powerful.

In a number of countries the education authorities have policies which approve or recommend the hardware to be used in schools. Often these policies have also affected the availability of software for the schools and consequently the use of the computers across the curriculum. In some countries, the policy has been to approve or recommend only hardware designed, developed and produced within that country, with the intention of fostering and supporting local computer and software industries. Even though at the time of approval there was very little software available for the chosen equipment, the policy has been to wait until software has been developed for it rather than to import hardware and use or adapt existing foreign software. In some countries, the policy appears to have been successful in developing a software industry, but in others it appears to have held back developments in the use of computers across the curriculum especially when the development of a local computer industry has proved to be financially unviable.

Another effect of there being little hardware and little software is that the identification and selection of quality software virtually disappear as issues for teachers. One does not spend much time searching for pools of cool, clear water in the midst of deserts!

Factors related to Software

A typical scenario

The following comments by teachers quoted in the Australian evaluative study of the National Computer Education Program illustrate the problems (Bigum *et al.*, 1987). Similar comments can be drawn from the literature in most OECD countries.

The aim was clear enough:

> "When I was enquiring into the type of system to install I was asked the question: What do you want to use the computers for? This was the question that had to be answered as everything else evolved from here ... computers across the curriculum was stated as our aim. We envisaged word processing in English; database research in history, geography, commerce and economics; real world use of database information in economics; mapping, simulations, etc., in geography; drill and practice in science, maths and English; discovery through reasoning in maths and science; even religious education could use databases, quizzes, word processing, etc. Art and music could also make use of computers via the appropriate software. So my 'dream', in particular, was to have the girls totally familiar with computers, not just through a computer awareness course, but by their use in as many subjects as possible across the curriculum" (a computer co-ordinator, in Bigum *et al.*, 1987, p. 90).

But keeping up with the information was difficult, even for the enthusiast:

> "I cannot keep up with the information – I get three magazines a month and the way things are changing is just phenomenal. I would be lucky if I could store information in

my mind about what is happening every month with regard to three aspects of computing because suddenly, instead of being computing, it is now communications and communications is things like databases or replacing colour films, TVs and that type of thing (videodisks) or using the radio waves to bring information in ... It is really phenomenal. I can't keep up with it, I have a large amount of time available to me but the change is just too quick ... I make a comment today and tomorrow that comment might be meaningless because something else will have replaced what I have told you" (a computer room manager, in Bigum *et al.*, 1987, p. 103).

Software was not a problem in one school:

"Software is not a problem in this school because so few teachers use the computers. ... the problem is circular – insufficient hardware and software to convince teachers to incorporate the use of computers in their teaching and, consequently, insufficient demand to justify the need for more software and hardware" (Bigum *et al.*, 1987).

There is software, but there are also priorities:

"Software is now becoming available, but, when you look at the software and the price of it and when you look at your own needs in terms of other resources in the school including textbooks and audio-visual material, then at this stage our priority must go to audio-visual and textbook material. We know how to use traditional materials and they seem to be more relevant" (a science teacher, in Bigum *et al.*, 1987, p. 120).

"One brochure in 20 that I receive has to do with computer software. I firstly look to see that it's computers. Secondly, I look to see the price. When I see the price, I think that I have $800 to spend for the rest of the year. I don't have access to a computer. Where are my priorities? So after I look to see it's computer software and price, then straight away I put it to one side. For Walgunyah that means that computer education is being put to one side at least in my area for some period of time" (a social science teacher, in Bigum *et al.*, 1987, p. 124).

And some of the software is not very good:

"One of my main concerns is the language attached to computers. It really gets on English teachers' nerves – 'Computer friendly', and stupid instructions. You never have a capital letter or any punctuation. As English teachers we flog our hearts out, year in, year out, trying to teach punctuation, then the machine has none of that kind of thing in most of the programs. One would like a more suitable and contemporary Australian language as compared to this obnoxious and nauseous American salesmanship language" (an English teacher, in Bigum *et al.*, 1987, p. 121).

We need to be able to see software before buying it:

"Then there's the problem about access to software. If I hadn't been able to obtain a loan of a copy of the Bushrangers program from a friend, I would not have been able to convince those people in the English department to spend $100 on software. When we first bought the computers and we were all a lot more ignorant, we paid $300 for a set of tapes for our Microbees and they're useless! We weren't aware then, as we are now, that the quality of the software varies so much. There's an individual taste thing even within good software as to what's applicable to your classroom. So you really need to be able to see software and most companies, because of copyright problems I imagine, are reluctant to send software on approval. So you buy sight unseen and, particularly in a small school such as ours, we haven't got the money to take risks buying sight unseen. However, we're not close enough to big centres where we can get to see stuff. You often get: 'Well just pop into any of our shops and have a look at it'. Well that's just not possible" (a teacher, in Bigum *et al.*, 1987, p. 122).

Even when available, good software is not always integrated into the curriculum:

"We have two very interesting history programs. We have the First Fleet one and the Bushrangers one which are both fantastic ... They should be used by the history teachers but aren't very much. I'm quite sure the First Fleet one is used only in the most rudimentary way. We have the full book and heaps of exercises where you can start to manipulate, analyse information and begin to try to do correlations on interesting historical details. But to my knowledge, the only time it's ever been used in Year 9 is to type in a kid's name to see if the name comes up as a convict's or something equally basic. Really that's about all that's been done, just reading through the actual information about convicts, not actively using the information" (a teacher, in Bigum *et al.*, 1987, p. 120).

Some of the conclusions of the study were:

"There appeared to be three main issues that related to software in schools. First, teachers find it very difficult to identify software that they believe will be useful in their own teaching. ... the second issue is related to the fact that much of the existing software is difficult to integrate into teaching because it is either too easy, too hard, or it takes too long before useful results are produced. A third problem is that often teachers must put in a great deal of preparation time before the software can be used in the classroom" (Bigum *et al.*, 1987).

The scarcity of quality software

Although it is difficult to generalise about the quantity, quality and scope of software available in OECD countries, detailed information not being readily obtainable, it would appear that in most countries software for use across the curriculum has not been available and that in many instances the quality of existing software has been less than satisfactory. Although the situation is improving, it is doubtful whether there is yet the critical mass of software which is needed to realise the full potential of the information technologies.

Komoski (1988) estimates that 1 500 - 2 400 new packages are published in the United States each year and that the proportion of good quality software has increased over the past five years from 5 per cent of the available to 12 per cent, with another 18 per cent of tolerable quality. However, in his view, there is still not the required critical mass of software available in the United States except perhaps in the area of mathematics.

Figures indicating the growth in the availability of software in other OECD countries show a very much more limited volume of software packages. Gilbert (1985), discussing the number of software packages needed in the United Kingdom to cover the needs of schools, quoted three positions. The first was that 200 000 single-topic packages would be needed to cover the needs of students between the ages of 5 and 16, allowing for differing student abilities and teaching approaches. The second was that schools would need only very few multi-purpose packages. The third was that there would be a continuing need for a mix of about 4 000 to 5 000 single-topic and multi-purpose packages for the secondary school and another 1 000 for the primary school with an annual growth of about 1 000 titles per year. The total range of software available in 1988 for the BBC Acorn, the microcomputer predominantly in use in schools, appears to be approximately 2 000 to 2 500 packages, a considerable shortfall on the third position quoted by Gilbert.

In France the *Catalogue des Logiciels* published by the Ministry of Education lists some 700 packages. Based on the work in reviewing software of the Coopérative des Enseignants et Personnels de l'Education Nationale (CAMIF), however, Lafay estimates that 10 per cent of French software is of excellent quality, 60 to 70 per cent is useful and only 20 to 30 per cent is of poor quality. He points out, moreover, that on average more recent software packages are superior in quality to older packages (Lafay, 1988). Even granting that 80 per cent of all packages are useful and that the number of packages available is far more than the 700 packages officially listed in the Catalogue (perhaps as many as 1 500), it does not appear that there is a critical mass of software across all the subjects of the curriculum in France.

Some countries with small and economically unviable software markets rely heavily on imported software. Although a great deal of such software is suitable, much is also often unsuitable. For example, the Australian software market is largely dependent on imports from the United Kingdom and the United States to supplement the few hundred Australian-produced packages and totals perhaps 3 000 packages for the range of microcomputers available. It too has its fair share of poor software. Software imported from other countries, even of the same language, sometimes creates difficulties with regard to curriculum content (is this subject matter taught here and at what level?), differences in pedagogy and educational practice (is this teaching method used here?) and the question of cultural differences. These difficulties are expressed quite succinctly by one Australian commentator, J. Anderson (1986):

> "Classic programs like Odell Lake and Oregon Trail which are well known to Australian students introduce users to species of fish that are American in origin and to aspects of American history. This is not in itself a bad thing but why not a trail based on Sturt's expedition crossing the continent or on the puzzle of Australia's westward flowing rivers?".

Some imported software is not considered good educational practice. As J. Anderson says:

> "More insidious than programs reflecting an alien or foreign culture is software that promotes regressive educational methods and philosophies. Examples of spelling and language, the focus on the heritage of other countries, and the use of non-metric measures are, after all, fairly easy to see. Less easy to counter is the mass of educational software, promoted by commercial interests, based on numbing drill and practice. Such software is quick to produce and often teachers are not directly involved in its development; its widespread adoption in schools runs the risk of gravely retarding educational practice".

On the other hand some software does appear to transcend cultural and language differences. It is interesting to note, for example, that many teachers in Australia are equally quite at home with software such as *Granny's Garden* from the United Kingdom, *Where in the World is Carmen San Diego?* from the United States and *Dinosaur Discovery* from Australia.

The lack of quality software not only hinders the growth in use of the computer across the curriculum, it can also distort it. Activities are undertaken which fit the curriculum to the available software rather than fitting the software to the curriculum need.

The cost of software

A factor which certainly has an influence is the cost of software. This is particularly so with schools which have many priorities and only a limited budget for the purchase of all materials including software.

> "Apart from the mass of public domain software, which is usually of little use, the software which is commercially available is often very expensive. This becomes even more critical if the school needs to purchase multiple copies of the software and the

supplier is not able to offer a site licence. A book costing $50 would contain several times the information as would a $50 program" (Bigum *et al.*, 1987).

Software publishers can, however, explain the high cost of software by the relatively small market for educational software. There is unfortunately, a chicken-and-egg situation. Software will remain expensive while the market for it is small and the market will remain small while the cost is high.

The lack of access to software information by individual teachers

In many countries information about effective pedagogical practices, whether in the form of software packages or in the form of examples of "good teaching practice" using the new information technologies, is not generally readily available to teachers. The report of the Scottish Education Department (1987) on *Learning and Teaching in Scottish Secondary Schools: the Use of Microcomputers* says, for example:

> " ... the general absence from schools of such lists (of software) and of the dissemination of information within schools on local and national software sources, inhibited the use of microcomputers by many teachers. Most were not aware of nationally distributed catalogues ... and tended to rely for information upon commercial catalogues, microcomputer magazines, educational journals or informal contact with colleagues. Since often only the particularly interested teachers were sufficiently motivated to track down packages, there was a danger that the range of resources already provided was not being exploited, with staff tending to use only the few items they had encountered and with which they were familiar. Conversely, and in more then one case, duplicate purchases were made through ignorance of what was already in the school".

Teachers seeking software face a daunting task in making responsible selections. The large quantity of published software and the large number of suppliers who would have to be contacted, make it virtually impossible for individual teachers unaided to identify what software is available. They may have to pursue enquiries through an unco-ordinated array of individuals, formal agencies and informal associations at local, regional and national levels. Not only is the job time-consuming, it is hit-and-miss. First, because the teachers have no way of being sure that they are calling upon all likely sources of assistance. Second, because those sources do not always have systems capable of handling a regular flow of routine enquiries.

When searching for information about software, teachers will wish to be provided with the answers to the following questions: What software capable of meeting my curriculum requirements has been produced, by whom and how much will it cost? For which microcomputers is it available? Is any special hardware or software needed for its use? What are its contents? What is it intended to do? Who is the target audience? Where can I preview it? Where can I obtain a copy? What do others think of it? How up-to-date is this information? Are there case studies, curriculum guides or descriptions of classroom implementations of the software that are relevant to my needs?

Even when they can identify what software is available, teachers still have to decide how useful it is. Often the only sources of information available are the publishers' brochures. Even assuming that each item has an adequate description, the task of sifting through these is considerable. At best, basing a selection on reading a catalogue is not following good curriculum practice. The risks are high that the product will be educationally inappropriate or technically deficient or that it will simply fail to perform the task for which it was bought.

Recommendations from colleagues can help. If the colleague has used a package with a group of students in a similar context to the desired use, then the advice might be worth taking. Unfortunately not all teachers have available to them the support of a helpful and informed colleague with encyclopaedic knowledge.

Opting for products from software suppliers or authors whose previous work has proved satisfactory or whose products are best sellers can help, but this then leaves overlooked the value of products from other less well-known sources. In any case selection ought to be based on professional judgement and a personal assessment of need.

The lack of reliable and trustworthy reviews or evaluations

Teachers need reviews and evaluations of software to help them in their search for software. However, reviews are frequently not available and those that are available are often limited in scope and unreliable.

Reviews should give teachers concise, accurate information and describe the main features of the software, both good and bad. They should be written primarily by other teachers who have experience in classroom use of the item.

> "Evaluations of this kind will make no value judgements concerning the desirability of treating a particular topic in a particular manner: This is a task for the teacher, who needs objective information concerning the program's pedagogic and subject content models in order to determine whether it is worth spending time on running the program to evaluate its appropriateness for particular teaching situations and needs" (Johnston, 1987).

Unfortunately, as the Scottish Education Department report referred to earlier says:

> "Teachers frequently experienced difficulty in deciding which software to acquire because of a lack of authoritative advice about the software or the criteria which might be applied in assessing it, or because of lack of easy access to preview facilities. Reviews in educational journals were valued but were almost always of software which did not originate in Scotland and which had uncertain linkage with the Scottish curriculum".

Even in countries where software reviewing agencies have been set up and considerable effort has been put into reviewing software, there is still a lack of appropriate reviews that teachers can consult. Moreover, questions are asked about the reliability of existing reviews to forecast the effect the software will have in the classroom. The OTA report has shown, for example, that approximately only 21 per cent of software available in the United States has been reviewed by eight of the most reputable agencies in Canada and the United States and that even those agencies can be faulted for not adequately incorporating field tests results and for providing only partial information about implementation strategies adopted by teachers.

Teachers should be aware that reviews are only a guide or a pointer. They are only one element in the process of selecting software. Perhaps equally as important are case studies and descriptions of curriculum implementations of the software in the classroom.

The lack of adequate previewing and demonstration facilities

Many teachers do not have access to central or school facilities which provide them with the opportunity to preview software or to see software demonstrated.

Having identified a potentially useful piece of software, teachers need to evaluate it for use in their classroom in much the same way they would evaluate any other curriculum material before purchasing it. Even though reviews can help, conscientious teachers selecting software still need to preview software prior to purchasing it to ensure that the software does in fact meet their requirement. In the final analysis teachers still have to look at the software for themselves and decide whether a particular package is useful to them. Often what is useless to one teacher can be extremely useful to another in different circumstances with different types of students.

> "There is no substitute for first hand, personal evaluation by the classroom teacher, but it is a lengthy, often involved process, especially with the more educationally rich and complex software" (Johnston, 1987).

A possibility is for the individual teacher or school to acquire copies for preview from the software supplier. Here the teacher can encounter major difficulties depending on the preview policy of the publisher or supplier. Some do not allow previews; others do not allow returns; yet others allow preview only of a demonstration diskette which may or may not be representative of the entire package. Such restrictions are perhaps excusable if not justifiable in view of the high cost of developing quality software and the problem of software piracy.

Another possibility which has been tried successfully in some countries is the establishment of preview centres at the local, regional and national levels. Often in collaboration with the software suppliers, such centres maintain libraries of software and other materials which teachers can examine, perhaps on the occasion of professional development activities. Such preview centres often allow teachers to borrow software for the purpose of evaluating it or arrange for software to be made available to schools more distant from the centre. Unfortunately, such centres are rare.

Factors related to the Teacher

The lack of appropriate training for teachers

The availability of appropriate information, of reviews and evaluations and of suitable opportunities for teachers to examine software in order to assess its potential use in their classrooms is of little value unless teachers have the skills both to judge the value of software and to integrate its use effectively to meet specific curriculum and learner needs. However, the majority of today's practising teachers have never received appropriate training in these skills. When most of them obtained their pre-service training, the use of microcomputers as teaching and learning tools was unknown. Nor have in-service programmes dealing with these aspects of the use of software generally been available to them.

> "A particular need is that of training teachers in the selection of good software, which is clearly not a trivial task. As the attitudes, values and priorities of teachers are crucial to the success or failure of the microcomputer in education, since it is teachers who will have to implement the innovation, teacher training in program evaluation is important to the future direction of computer-assisted learning across the curriculum" (Johnston, 1987).

Even where it would appear that training programmes have been available, they have not always been effective. In France, for example, where one-quarter of the teaching force was trained in the use of microcomputers, it is now believed that the courses they attended lacked an adequate pedagogical base and did not provide the necessary experience in actually applying computers in the classroom. Use of microcomputers in the classroom remained steady or even declined; equipment was underutilised and teachers were disaffected (Ministère de l'Education nationale, 1985b).

The task is formidable. As Komoski (1987) has said:

> "The idea of learning to teach using simulations, gaming, and database exploration is not one that is eagerly embraced by every teacher – especially if they have had no experience with or training in how to integrate such teaching and learning approaches into the curriculum. Hence, the task of developing the necessary awareness and discrimination that teachers need to search out and select the very best software for the teaching and learning of specific curriculum goals is a formidable one. In order for one to become discriminating about anything, it is necessary to become very familiar with it. Teachers are no exception to this rule. And parents, who are an important part of the educational software market, are at even more of a disadvantage than the average teacher, who has much more of an opportunity to become familiar with computer software".

There is a Catch 22 situation in the relationship between the expertise of teachers and the quality of software available on the market. As Komoski says:

> "Although the majority of the software that teachers are becoming familiar with is poor or mediocre when compared to the best available, this familiarity seems not to be breeding the contempt that one might expect. Perhaps this will happen as teachers' powers of discrimination improve. But until this does happen, we can expect to see little improvement in the overall quality of microcomputer software being marketed to school and home consumers. In the meantime, we can only hope that those who are helping teachers to find out about available software will make every effort to direct them toward using only the very best of what is available. For it is familiarity with the very best that may raise teacher expectations about the rest. ... school and home consumers of educational software are not sufficiently discriminating about what they are purchasing, and therefore, there is little incentive for software producers to invest in the more substantial cost of developing higher quality software – especially when low-cost, low-quality software continues to sell briskly. ... further compounding of this problem occurs because many teachers are more comfortable with software that has the look and feel of the traditional textbook/workbook mode of instruction".

This point is taken up by Johnston (1987):

> "The evaluation of microcomputer programs is unlike that of learning materials in other educational media in general, and of the book in particular, in that software is not readily accessible to inspection by skimming, scanning and the selection of random parts for detailed examination. It has to be run in real time, and explored in detail both as an expert user and as a learner novice... documentation can help ... but the only way for a teacher to determine a program's suitability for a particular educational purpose and teaching style is to run it and explore it thoroughly".

The lack of support for the teacher

Among the reasons given by teachers in Brittany (France) for their teaching style remaining unchanged after using computers for two years were the lack of a support centre in close proximity and the lack of specialised personnel such as a school computing co-ordinator and subject advisers who had time release from teaching to help them in the school.

Similar comments are to be found in the evaluative study on the Australian National Computer Education Program of 1984-86 (Bigum *et al.*, 1987).

The Resistance of Education to Innovation

Teachers in general seem to resist technological progress and may appear to be the biggest stumbling block inhibiting changes in the way computers are used in schools. They are not, however, entirely responsible for this, since, as Gilbert De Landsheere has said:

> "The methods that teachers use are governed by beliefs and attitudes that have been deeply and unconsciously absorbed during their school career, which in some countries begins at the age of three in the case of more than 90 per cent of children and thus lasts at least 15 years up to the end of compulsory education. That is why, when they themselves become teachers, they tend to copy the teaching techniques that were used when they were at school and not the techniques advocated by more recent teaching theory. Before training anyone to use these new technologies, or, more accurately, concurrently with this training, the underlying attitudes and habits of educational practice need to be thoroughly reformed. This will be a complex and costly operation and will only be achieved by working together with the teachers over a long period of time and by endeavouring to resolve jointly the problems that they have decided to tackle" (OECD/CERI, 1986).

Teachers are, of course, not the only obstacle to innovation and change in education. Often it would seem that in many countries either the education system itself or the lack of commitment on the part of the education system is the biggest obstacle. When all is said and done, it is the system which has trained the teachers and the teachers are products of the system. Before the teachers can be expected to change, the system which made them what they are must change too and become much more open to innovation.

In most countries the use of computers across the curriculum has developed through the efforts of enthusiastic teachers and devotees as a grass-roots movement. It has not been accepted by the decision-makers nor has it been institutionalised as part of the system. Often it has a low priority, as is clear when major funding decisions are handed down. Whilst the potential of computers will never be realised without the active participation of the teaching profession, their use across the curriculum will never be anything more than a fringe subculture in education without the support and commitment of governments and education authorities, expressed for the most part in terms of hard cash.

Some countries have recognised these realities and by ongoing national policies and programmes are trying to come to terms with them. Other countries have been content to take a once-off, shot-in-the-arm approach by funding programmes of limited duration. Yet other countries seem prepared to allow developments to take place at the grass-roots level without any significant top-down intervention.

Chapter 2

EDUCATIONAL SOFTWARE: THE CONCEPT OF QUALITY AND THE TYPES OF SOFTWARE

The identification and selection of high quality software that can be integrated into the curriculum are of primordial importance in the use of the information technologies. Being able to determine what constitutes quality in software is also of the greatest importance. In order to identify quality software and to help teachers select it, considerable effort has been spent in a number of the OECD countries to develop agencies for the review and evaluation of software. Before describing activities in these countries, it is appropriate to consider the characteristics that determine quality in software, and to discuss the different types of educational software.

QUALITY IN EDUCATIONAL SOFTWARE

The concept of quality in educational software, of what makes a piece of software a good teaching or learning resource, is complex and extremely elusive, largely because it is the result of the interaction of a number of variable factors which themselves are complex and difficult to define. These factors include the subject matter being taught and the curriculum, teaching and the teacher, learning and the learner, the technology itself and the type and design of the software being used, all of which are subject to extremely rapid change and development but which interact synergistically in varying degrees to make a piece of software an effective teaching or learning resource. At the international level these factors are compounded by national and cultural differences which can cause a piece of software considered excellent in one country to be judged of little value in another.

Forming an assessment of the quality of a piece of educational software is equally as complex since it must take into account the same factors but is further complicated by the personal viewpoint, expertise and experience of the assessor. It is also complicated by what can be called the *Rear View Mirror Syndrome*, the danger of viewing software, as it were, through the rear view mirror, of looking backwards instead of forwards, of comparing software with yesterday's standards, of being content with yesterday's technology and developments in the cognitive sciences, the curriculum, teaching and learning instead of looking for and demanding tomorrow's new technologies and developments. The syndrome has a largely negative effect on quality in educational software, often resulting in a static view, whereas information technology in the curriculum is, on the contrary, a dynamic, developing field that is very hard to keep up with – these are the days of disposable software – and that constantly offers new challenges and opportunities.

The rapid change and development in educational software were referred to by Olds in 1983:

> "Software development is still in its infancy. What was considered state-of-the-art a month ago is less than adequate next month. We are where the Wright brothers were at Kitty Hawk – just barely off the ground".

It is clear that we have not flown more than a few metres in the last five years and that there is a very long way to go before Concorde flights are a regular part of the educational scene, let alone space shuttle and interplanetary flights.

Quality of Educational Software and the Curriculum

Many of the ways in which the information technologies have affected the curriculum can be measures of the quality of software. All the following can have a part to play in the assessment of the quality of software: the extent to which a piece of software encourages the development of higher-order skills; the extent to which it encourages the use of exploration and discovery; the extent to which software fits the curriculum or has an appropriate place in it; the extent to which it adds something to the curriculum or improves it by allowing something to be done which was not feasible previously.

The subject matter itself also has to be taken into account. Thus the degree to which the subject matter of the software reflects the best current thinking in the curriculum area it addresses also has a bearing on the appropriateness of a piece of software and consequently its quality.

Quality of Educational Software and Teaching

The impact of the information technologies on teaching and teaching style has implications for the concept of quality in educational software. Whether and how teaching style is affected, the way in which teachers use software and what they consider to be the characteristics of quality in software can be indicators of excellence in software.

Just as there is no best use of technology and no best way of teaching with technology, so there is no one best piece of educational software, even for a particular task. One piece of software will be considered excellent because it encourages co-operative learning when appropriate; another because it encourages the individualised learning that is desirable at a different point in time. One piece will be considered of high quality because it can be used with the whole class and consequently fits the classroom management style of a teacher with only one computer shared by the 30 students of the class, whilst another is considered irrelevant because it has to be used by each student individually. Different ratings can be given to software by "experts" outside the classroom to those given by classroom teachers. Thus whilst the "expert" might emphasize subject-specific software, the teacher might emphasize *open-ended* software which allows students a substantial range of choices and decisions, and/or allows the teacher to adapt the program content to the needs of their particular student population.

Quality of Educational Software and Learning

In recent years there have been developments in our knowledge of how students learn and in the use of artificial intelligence. As yet few, if any, of these findings have found their way into the software which is being presented for use in Education. The extent to which software reflects this current thinking and the extent to which software developers are striving to incorporate it contribute to the quality of software.

The adage "The proof of the pudding is in the eating" is as relevant to the quality of software as for other products. How do students judge software, what do they think of it, what do they consider quality in software? Unfortunately, little research has been conducted into these questions. Malone (1980a) found that students were motivated by many of the same factors which motivated them in their use of arcade games, for example, having a goal and a sense of competition, the computer keeping a score, the audio and visual effects of the software, the fantasy created and so on. Smith and Keep (1986) have found that the children in their study had well established criteria against which they evaluated educational software. In most cases, their immediate perception of the computer was as a device for playing games at home and of computer software as consumer goods which were evaluated against the production and presentation standards of the consumer market.

Quality of Educational Software and the Technology

A common complaint by teachers is that educational software is often evaluated only in terms of its technical qualities without due emphasis being given to educational considerations. While, if this were true, an unbalanced view of software would be obtained, failing to consider the technical qualities would give an equally unbalanced view of software. Moreover, the quality of educational software from the technological aspect is not simply a question of whether the program works but rather of whether and how well the software makes appropriate use of the capabilities and facilities of the hardware and software environment and of how well it incorporates and reflects the latest developments in the technology. Thus in looking for excellence of quality in this respect one would expect such hardware features as high resolution graphics, quality sound, the use of other technologies such as speech synthesis, videotapes, videodisk, CD-ROM or audiocassette to enhance the learning experience; the appropriate use of alternative input devices such as voice, light-pen, mouse and graphics tablet.

In its technical aspect educational software must also be seen against the background of commercial software, and in many respects – such as the quality of presentation and use of features such as graphics and sound – must be judged by comparison with it. A characteristic of commercial software is that it is often transitory. Most commercial software is a consumer product with a life span of 3 to 5 years. New techniques and standards for software are developed each year. New versions of software appear on a regular basis and products are superseded by competitors' products. What was not done in a program one year because it was too difficult, becomes easy the following year through the development of new techniques. What was innovative one year, is accepted as standard practice the next. Fashions in presentation change, even with software, and what appears very chic, engaging and interesting one year, is passé, drab and uninteresting the next.

Unfortunately education often cannot take advantage of the more advanced software systems now being produced since the hardware requirements for the software exceed the capacity of hardware generally available in schools. In many countries much of the school computer equipment is technologically crude compared to the systems available in business and science. Typically, for example, school computers have 8 bit processors, operate at a quarter the speed and have only low resolution screens.

Although to a lesser extent, there are also fashions in educational software, quality is often transitory and what appeared to be an excellent program five years ago is today considered rubbish (there are exceptions to this, programs which have stood the test of time, for example, *Green Globs*). Early educational software lacked many of the features which today are taken for granted, for example, the facilities of exiting the program at any point and returning to that point directly on another occasion or of going back through the program to review responses and content.

THE QUALITY AND TYPES OF EDUCATIONAL SOFTWARE

A significant number of types or modes of educational software have been developed. Each has criteria by which its quality can be judged. It is important that one type not be assessed by the criteria of another. For example, a drill and practice program might be considered excellent because it provided a high level of interactivity and individualisation, both of which properties would be inappropriate in a database management system. The criteria for judging a tutorial are different from those used for judging a spreadsheet or a word processing package.

A number of taxonomies of educational software have been constructed. The evaluation study of the 1970s National Development Programme in Computer-Assisted Learning in the United Kingdom, for example, invented four educational paradigms with which to relate computer-assisted learning to the general field of education. The four paradigms are the instructional, the relevatory, the conjectural and the emancipatory (Rushby, 1979). A well known framework for considering the various types of software is that of Taylor. The computer is seen in one of three modes – tutor, tool and tutee. In the first mode, the computer as the Tutor, the computer teaches the student in some way. In the second, the computer is the Tool which is used by the student and in the third mode, the computer is the Tutee, which is taught in some way by the student (Taylor, 1980). The OECD/CERI report (1986) *New Information Technologies: A Challenge for Education* distinguishes categories of software according to the amount of control and independence of the learner vis-à-vis the computer. At one end of the spectrum are computer-controlled drill and practice programs, whilst at the other are student-controlled programs in which learning is viewed as an active process of investigation.

Educational software is available in most subject areas and for most types of users, including those with special learning needs whether at the pre-primary, the primary, the secondary or the post-secondary levels. The reader is referred to authors such as Goldenberg *et al.* (1984), Hawkridge *et al.* (1985), Saunders (1984), and Rostron and Sewell (1984) for further information on the application of the information technologies to Special Education.

The following brief description of the types of software includes examples of some of the better packages of each type. They are neither mutually exclusive nor exhaustive. The reader is referred particularly to the 1987 OECD/CERI publication *Information Technologies and Basic Learning: Reading, Writing, Science and Mathematics*, which gives an excellent overview and numerous interesting examples of the different types of software predominantly used in the four areas under consideration.

Drill and Practice

This best known example of Computer-Assisted Instruction (CAI), which has been in use for nearly 30 years, is based on a behaviouristic approach to learning and earlier experience with programmed learning. The computer is used to reinforce concepts previously learned by the student, much as a worksheet or problem assignment is used in a traditional setting. In general, no new concepts are presented to the student. Typically, the program presents some subject material, asks a question, evaluates the student's response, provides some feedback to the student and presents the next lesson frame on the basis of the response to the previous one. Some drill and practice packages have an integrated management system and keep a running cumulative score of the student's successes and failures.

Early CAI systems were provided through large time-sharing mainframe computers which were needed to accommodate the materials required for the entire span of the curriculum. The best known examples of such systems include PLATO (Programmed Logic for Automatic Teaching Operations) at Illinois University and the Stanford University project in elementary reading and mathematics skills. Although the advent of the microcomputer has eliminated the need for the mainframe computer system, much of the available CAI has remained virtually unchanged in character.

Earliest examples of this category of software employed a restricted form of dialogue, presenting only multiple choice or text completion questions and making little use of graphics. Courseware packages based on these principles, although with improved readability and the use of graphics, have been and continue to be produced in the thousands. Unfortunately, as long as teachers continue to be undiscriminating in their purchases of software, software suppliers will continue to meet the demand. A number of simple authoring systems have also been produced which allow teachers to construct their own packages.

A number of the commercially available "basic-skills" software packages are examples of this category. Howe (OECD/CERI, 1987a) considers that the best available today in the mathematics field have been designed for use at primary level. He breaks them into two categories, number and space, and quotes a number of packages, produced in the United States, as examples, including: *Targets* (Sunburst), *Arithmagic* (QED), *Minus Mission* (DLM), *Teasers by Tobbs* (Sunburst), *Code Quest* (Sunburst), and *Funny House Maze* (Sunburst).

Although often highly motivating, the use of drill and practice programs is frequently criticised on the grounds that drill and practice tasks could be done just as easily without computers and that it promotes passivity on the part of the user. Howe questions the effectiveness of such software and concludes that the short answer is that the evidence is equivocal. Some evaluation studies claim significant gains in mathematical performance and enhanced motivation; some suggest that gains are made by increasing the amount of drill and practice whether computer-based or not; some fail to show any benefit accruing to pupils; others that the two categories of pupils benefiting most from exposure to drill and practice programs are pupils in the early years of primary school and lower ability pupils. The OTA report (1988), on the other hand, states that the effects of CAI are generally favourable, but that much of the research conducted into it can be criticised on methodological grounds. It points out that "the main problem with the results of this 30-year body of research is that it provides no insight into how CAI produced these learning outcomes".

Tutorial

Tutorials are closely related to drill and practice. The software takes the form of a dialogue between the computer and the student in which the computer instructs the student in learning new material or in improving his/her knowledge of material studied previously. Tutorial software usually includes quite sophisticated means of analysing the student's responses to the computer and of varying the computer's part of the dialogue depending on the student's response. The aim is to make the computer behave in the same way as a real teacher, thus creating the possibility of replacing the teacher or at least of substituting for him/her when not available. Many tutorial programs take advantage of high resolution graphics and colour to enhance student motivation. Drill and practice is often used in a tutorial system to reinforce the concepts presented and there may also be links to other modes of presentation such as simulations.

Howe considers that although there has been a significant increase in the availability of good conventional tutorial programs for mathematics at school level, there are still relatively few good tutorial programs. However, as he says:

> "The use of the word 'good' should be qualified as a subjective judgement since the educational effectiveness of these programs is still open to doubt. In general, their diagnostic capability is crude, leading to the criticism, as yet unrebutted, that they cannot teach as effectively as a human teacher".

Among exemplary packages in the mathematics area produced in the United States are: *Bumble Games* and *Bumble Plot* (The Learning Company), *King's Rule, Number Quest* and *Tobbs Learns Algebra* (Sunburst Communications) which combine mathematical content with mathematical process or strategy; *Equations, Magic Grid* and *Solving Equations* which are concerned with solving equations; *Polynomial Practice Using Tiles* which is concerned with operations on binomials, monomials and polynomials (Howe, 1987).

Tutorials of varying quality are available in many of the science subjects, including physics (mechanics, heat, light, gravity), earth science (meteorology, geology, astronomy), chemistry (atomic models, periodic table, formulae, equations), ecology (acid rain, land and water analyses, pollution), biology (anatomy, circulation, cells, plants, photosynthesis, zoology, dinosaurs), health science (nutrition, the harmful effects of AIDS, alcohol, drugs, tobacco, venereal diseases) (Le Corre, 1987).

In some instances the software is part of an integrated multi-media package of learning materials. One example of this is the *Voyage of the Mimi*, which includes 13 episodes with 15-minute television documentaries, a 160-page book, a teacher's guide and four courseware modules, each with teacher and student guides. During the course of an exciting whaling expedition a whole series of concepts, operations and factual details are introduced: whales and their environment, measurement of the physical characteristics of sea water, reading a chart, methods of navigation, meteorology, solar energy, ecosystems on a desert island, and repairing a ship.

A good example of effective dialogue is the series of physics tutorials developed at the Educational Technology Laboratory, University of California, at Irvine. These are in the form of quizzes which switch over to a tutorial mode as soon as the student encounters a difficulty (Bork, 1981).

Examples of tutorials in the social sciences are the series on *Nationalism, Revolutions* and other historical topics by Focus Media (United States).

Intelligent CAI or Intelligent Tutoring Systems

A number of programs have been developed which go further than previously created tutorials and use a model of the student to provide activities matching the existing knowledge and learning strategies of the individual student. The programs have the capability of intervening if the student does not adopt an effective learning strategy. Such programs, which are a form of artificial intelligence, are known as Intelligent CAI (ICAI) or Intelligent Tutoring Systems.

In the tutorials described above, instruction is controlled by the developer of the program, who determines what is presented, how much information is presented, the order of presentation and the specific questions to which the student must respond. The program cannot respond to students' questions, responses or problems that are not specifically designated or predicted by the programmer. An intelligent tutor, on the other hand, has an explicit representation of the knowledge that the student should acquire, an extensive catalogue of error types and their origin, with related hints and explanations, and a teaching model which decides when to interrupt, what kind of help to give, what type of problem to give next and when to move on. The student's control over the computer is therefore theoretically increased and the student learns by doing. ICAI can generate and solve problems, store and retrieve data, diagnose students' misconceptions, select appropriate teaching strategies and carry on dialogues with students much more than is possible with ordinary tutorial systems.

Howe (1987) describes a number of intelligent tutor systems and gives an overview of the research into these systems. One such program is that described by Shute (1987), which encourages students to develop scientific approaches to economics. It contains a database of economic facts about a hypothetical town together with a computable model used to present patterns of figures and tools which enable relationships to be deduced from facts, using automatic tabulating and graphing facilities. If students adopt uninterpretable patterns of interaction, or if their deductions are consistently faulty, a computer tutor is brought into play which explains ways of using the database more systematically. It also corrects incorrect deductions. The tutor is activated by the student's interactions with the program but the advice is not otherwise individualised

Other intelligent tutoring systems under development at the University of Pittsburgh are described by Klopfer (1986) as computer microworlds or limited learning environments on a computer where interesting things happen, where there are *neat phenomena* and where important ideas are to be learned. He describes three microworlds, the *Electricity Tutor*, the *Eureka World Tutor* and the *Geometric Optics Tutor* and gives the following picture of an intelligent tutor:

> "Imagine that the computer software has the capability to recapture the special features of the classical apprentice system of teaching and that it can do this in a cost-effective way. Teaching in an apprentice system is highly individualised, and its best characteristic is that each apprentice always receives from the master exactly the kind of information and guidance he needs to develop his knowledge and skills to the fullest. The master is a true expert in her trade or subject matter, knowing not only its general principles and major trends but also a plethora of specific information. Her expertise includes a panoply of tested teaching strategies and procedures suitable for instruction in different aspects of the subject for different purposes and on different occasions. ... The science master would know how to use direct instruction, discovery approaches, simulations, drill, Socratic dialogues, problem-solving strategies and even the Suzuki method. In addition a successful master has detailed knowledge about each apprentice's stage of development and rate of progress, and she employs this knowledge to tailor the instruction for each individual apprentice. Finally, an ideal master not only possesses all the knowledge described but also is wise, so that she properly motivates and encourages each apprentice to persevere in developing his competence" (Klopfer, 1986).

Simulation and Model Building

With this strategy the computer is used to model the real world or some set of real conditions so that they can be manipulated and studied more easily. Simulations can cover a wide range of phenomena from planetary motion to historical events, from business environments to scientific experiments which would be too dangerous, too expensive or too time-consuming to perform in the normal laboratory. The user of the simulation can test hypotheses by changing the variables of the model and observing the effects of the changes within the environment of the simulation.

A number of types of simulation can be identified. Le Corre (1987) distinguishes between model-building simulations, in which the student has to determine the model, and behavioural simulations in which the model is given for the student to work with.

Simulation programs have been developed particularly in the physical and biological sciences although examples are also to be found in the social sciences and the business studies. Following are some examples of simulations:

Tribbles Families (Bork *et al.*, 1980) is a program in which the student behaves like a scientist performing experiments, collecting evidence and building a simple Mendelian model of genetic inheritance. The Tribbles, or extra-terrestrial creatures, are studied to determine their attributes, how to predict whether they will mate with each other and what rules govern the characteristics of their offspring.

In Millikan's experiment, the student studies the equilibrium of an electrically charged droplet under the combined effect of gravity and a vertical electrical field. This is a traditional method of demonstrating the discontinuous nature of electrical charges. Many versions of the simulation can be found in a number of countries.

Mary Rose (United Kingdom, Ginn) is based on the rediscovery of the Mary Rose, the flagship of Henry VIII of England. The first part of the package simulates the search for the wreck. Students navigate a boat surveying the seabed with the aid of a scanner. Objects discovered have to be identified and their positions marked. The second part simulates the underwater excavation of the hull. The package is a good example of a software package which can be used not only to teach the specific topic it deals with, in this case the Mary Rose, but also as the basis of projects in a number of areas. *Mary Rose* has been used, for example, to provide opportunities for projects in areas such as mathematics, problem solving, creative writing and history. It is also a good example of a software package which at first sight appears to have no relevance to any other curriculum except the one for which it was specifically written but which on closer examination has a much wider relevance and applicability. Hence, *Mary Rose*, although written around a specific shipwreck at a specific time in history and in a specific location, has been found, for example, to be an excellent starting point for students researching the shipwrecks around the coast of Australia.

The Sell series comprising *Sell Apples*, *Sell Plants*, *Sell Lemonade* and *Sell Bicycles* (United States, MECC) can be used to teach elementary ideas of business planning and business decision-making. In response to the user's decisions about volume of sales, price per unit, advertising expenditure and so on, the computer produces a financial report, displaying the company's performance in terms of units sold, cost per unit, net profit, etc.

Problem-solving

In problem-solving courseware the student has to find an algorithm to solve each problem. This may require the student to have a knowledge of computer programming. In other cases a program is provided and the student uses it to solve the problem.

In some cases the problem is solved by carrying out a straightforward calculation, for example, calculating speeds and angles after an impact, calculating the number of moles released in a reaction. In many cases the calculation is done by the computer once the student has clearly established the strategy for solving the problem.

Sometimes the problem to be solved is more elaborate and requires an analysis of errors in strategy. Examples of this are *Problem Solving in Science* by Bork *et al.*, and a CNDP (Centre National de Documentation Pédagogique, France) package called *Radac*. In the latter the student first learns how to write a reaction between an atomic nucleus and *alpha*, *beta*, *n* or *p* particles and then has to predict what types of particles are produced when all that is known are the nuclei or colliding particles.

In other cases the courseware aims to encourage logical reasoning. Best-sellers of this type in the United States include *Gertrude's Secrets* and *Gertrude's Puzzles* (The Learning Company), and *The Pond* (Sunburst Communications). In the last of these a frog has to find a successful pattern of lily pads by which to cross a pond. Only a portion of the pond is visible but the frog may explore the pond by jumping from lily pad to lily pad until it discovers a pattern.

An unanswered question with much of this type of software is the extent to which the skills developed in solving the problem – for example, finding the successful pattern of lily pads by which to cross the pond – transfer effectively to other types of problem.

Educational Games

Many software packages use a game format as a presentation strategy to provide motivation and reinforcement. For example, a gaming strategy is used in the excellent program *Green Globs* (United States, Conduit) to teaching graphing skills. In the game the computer displays co-ordinate axes with 13 green globs scattered randomly on the screen, and students are asked to write equations for graphs which will hit the globs and cause them to explode. The student is given immediate feedback by having his/her equation displayed on the screen. The computer maintains a "hall of fame" of students who explode the globs with the least number of graphs.

Although a game, *Green Globs*, has been very positively evaluated (Dugdale and Kibbey, 1980), the educational value of other games is not so clear-cut. In many of the drill and practice programs, for example, a video game is offered as a reward for getting a good score in a number of exercises and the student spends more time playing the game than doing the exercises. In other cases there is a tenuous connection with a learning activity. *Chemrain* (United States, Compress), for example, in which the student tries to keep inorganic compounds at the top of the screen from reaching the bottom by choosing organic compounds with which they will react, is the equivalent in chemistry of *Space Invaders*. Such games are also often used for positive reinforcement. Examples of this type are computerised versions of the pencil and paper game, *Hangman*, of which hundreds of versions must be available, and *Pac-Man* in which a flask is pursued by a beaker and has to find the right chemical compound.

Although the educational value of many of these games is debatable, it would appear that skills associated with data handling, discussion, research, planning, analysing, hypothesis generation and testing, forecasting, exploring, discovering, observing and organising can be developed through the use of some of them. Some can combine learning with entertainment and make it a pleasant experience. Others are pure entertainment and of little or no educational value.

A type of educational game which has developed in recent years and is quite popular at primary levels is the Adventure Game. Such games place students in a fantasy world in which problems and puzzles are presented and need to be solved before the students can progress. The aim is to accomplish a set task, such as finding certain treasure items within the unknown world. Although based on the popular *Dungeons*-type adventure games, it is claimed that educational adventure games "demand concentration and clear thinking, promote discussion, develop decision-making, problem-solving, language and comprehension skill, and assist in the development of spatial and directional sense" (Bell and Scott, 1985).

Some of the better known examples are *Flowers of Crystal* (United Kingdom, 4mation), *Granny's Garden* (United Kingdom, 4mation), *Dread Dragon Droom* (United Kingdom, RESOURCE), *Dinosaur Discovery* (Australia, Jacaranda) and *Fahrenheit 451* (United States). They can often be used to stimulate a number of process learning activities within the classroom. In *Dinosaur Discovery*, for example, students work their way through deserts and old mines to find a way of crossing the treacherous Stegosaurus Straits. Once safely across, they are faced with having to discover how to use a mysterious laboratory to hatch a dinosaur egg. To do so they have to use research, problem-solving, mapping and language skills. Such packages usually include teacher's guides full of practical suggestions for related classroom activities in many areas of the curriculum which might extend over many weeks.

Adventure game generators are also available. These are packages which allow students and teachers to write their own adventure games.

Information Retrieval and Database Management

Access to relevant databases and good data manipulation software can make possible activities in the social sciences and statistics involving the manipulation of data which would be virtually impossible without the aid of a computer. Some courseware involves student use of databases which are *fixed* or have already been set up for use. For example, the *One World Countries* database, which contains information about the countries of the world, *The First Fleet* database, which contains information about the convicts transported to Australia on the First Fleet in 1788. There are an increasing number of such database packages available on microcomputers.

Another use of databases is to allow students to collect their own data through observation or research, to organise the information into fields or categories, label those categories, make decisions about the kinds of data in those categories and then input such information into the computer for further analysis. Examples of activities in which students have been involved include the collection of weather data, ecological data, local historical data, etc.

For this, students need a general purpose database and information retrieval package. In some cases packages such as *DBASE III* have been used for this purpose but in general such systems have been too expensive and too complicated to be adopted by schools. Less complicated systems such as *Appleworks* and the the *PFS* products are often used. A few general-purpose information retrieval packages have been written specifically for schools. They include in the United Kingdom *Quest* (AUCBE) and *Find* (RESOURCE). A practice which is becoming more common is the production of ready-made databases for use with the general purpose retrieval systems. An interesting development with possibly considerable potential is the publication of *Hypercard* for the Apple Macintosh.

Word Processing

A large number of word processing systems have been produced for use at the various school levels. Many are published with extensive teacher's and curriculum guides with suggested classroom activities. The use of the computer as a word processor can facilitate the development of students' creative skills by enabling them to refine successive drafts, edit spelling and punctuation errors, and present good quality copy.

The use of word processors and other software aids to composition fits in well with the present methods of process writing. An excellent review of the available software aids for composition is given by Bruce (1987) under the headings of getting ideas, organising thoughts, composing, editing and revising, and obtaining feedback about one's writing.

Application Programs

Application programs are those which embody an algorithm that solves a particular problem or type of problem. Among educational application programs are those where the computer is used as an aid to the teacher. Some are used to perform certain of the teacher's non-instructional tasks, thus freeing him/her to spend more time teaching. Some examples are crossword puzzle generators, worksheet generators, random problem generators. Other programs known as authoring tools enable the teacher to generate computer-based tests and lessons.

Other application packages which have been developed for commercial use are also often used in teaching and learning situations. For example, many spreadsheet and graphics packages have gained acceptance with experienced teachers and are being exploited by them as new means of enhancing work in a range of subjects.

Computer-managed Learning

In Computer-Managed Learning (CML) the role of the computer is to assist the teacher in managing the learning process. It includes such uses as test construction and scoring, records management, the routing of students through courses and marksbooks.

Microcomputer-based Instrumentation or Laboratory (MBI or MBL)

In this category the microcomputer is used as a tool in the science laboratory. These laboratory tools consist of probes attached to a computer which measure various phenomena such as light, heat, temperature, brain waves, pulse rate and distance. MBL are used frequently in the teaching of the sciences, including the health sciences and technology. For example, students working with a sound probe can measure loudness or pitch, and the computer will record, display, analyse and play back the sounds being measured. Students can then modify the sounds and compose tunes by plotting a graph of pitches they select. In this way students can gain a sense of what is meant by the pitch of a tune.

Examples of available packages of software and appropriate connectors and devices are: a range of transducers for use as data collection front ends to microcomputers, including distance and velocity ranging, temperature measurement, light level and sound level detectors produced by the Technical Education Research Center, Cambridge, Massachusetts, United States; devices produced for the Microelectronics for All Project in the United Kingdom; the *Fischertechnik* series from Germany, which is made up of robotics kits that can be assembled like construction kits by the learner.

Exploration and Discovery

The classic example of the computer for exploration and discovery is the use of the programming language LOGO. LOGO was designed to provide students of an early age with the tools to explore concepts of geometry and mathematics and to construct models matched to their current level of understanding. The emphasis is on the development of thinking skills and problem-solving processes. It is claimed, for example, that the use of LOGO to solve problems by breaking them down into their components and solving each with a separate procedure allows children to experience a concrete approach to algorithmic problem solving. LOGO's attached floor robot, the turtle, allows children to explore spatial relationships in a concrete form.

The idea of microworlds has also been developed in other subject areas. De Landsheere (1987), for example, describes a number of examples of the use of the computer to create interactive language environments or microworlds which provide support to the student for the successful completion of reading and writing tasks. Other examples of microworlds are software packages which allow students to explore graphics and music.

The *Geometric Supposer* series (United States, Sunburst Communications) developed at the Educational Technology Center at Harvard University is another example. It provides students with the opportunity to discover or invent geometry for themselves by allowing them to make quick, accurate constructions on a particular geometric figure and then repeat those constructions. It frees them to use their intuitions and hunches to explore relationships among geometric shapes. This inductive approach covers the same content as the traditional curriculum and reinforces the need for proof which students use in their conjectures.

TRENDS IN EDUCATIONAL SOFTWARE

A number of trends can be identified in the way microcomputers are being applied in schools. Among them are the following.

The majority of earlier educational software has been directed towards teaching specific skills or specific topics in one curriculum subject. Much of the drill and practice, tutorial and simulation software is of this kind, aimed at teaching or testing the student's knowledge or skill in, for example, the addition of three-digit numbers, the spelling of a specific class of words, the knowledge of the points of the compass, or the simulation of an ecosystem, as in the examples given earlier. Many teachers find such software too limited in its usefulness and too expensive except for remedial work. This has led to a trend to look for software which allows teachers to input their own data, such as spelling lists or types of mathematical problems to be presented to the student.

There is also a trend, especially in the United States, to produce software which is even more specifically tied to school curricula and is distributed with textbook series. Also finding favour in the United States are Integrated Learning Systems (ILS), which use networked computers to deliver the curriculum, lesson by lesson and skill by skill. Some such systems include simulations and complex tutorials that in fact replace a curriculum based on textbooks with one based on software lessons. They manage instruction to each individual student and record his/her progress in very much the same way as the earlier mainframe computer-based systems did. One estimate is that such a system will be installed in a tenth of United States schools within the next five years.

On the other hand, there is also a very noticeable trend in some countries, including the United States, away from the more specific software towards the use of tool software such as word processors, database packages, graphics systems and music systems which can be used in a variety of ways. Sometimes the reason for this is the teacher's perception of the cost of subject-specific software and the limited use that can be made of it, together with the perception that the same amount of money from a very tight school budget will purchase a piece of software which can be used in many ways, over and over again. There are also very often sound pedagogical reasons for the purchase of such tool software, as the evaluative study of the Australian National Computer Education Program shows:

> "If teachers hold the view that the processes of learning are paramount – that flexible and adaptable thinking in the age of information technology is a requirement for all learners; that learners need to experience the organisation and interpretation of information in such ways that they skillfully construct and test their own knowledge; and that learning is the result of collaborative social interactions conducted under a variety of conditions – then they will create their plans for learning and using the computer as a tool in this process. The emphasis will be upon generic software: word processing, database construction, spreadsheets, simulation creation, graphics, computer languages, etc."
>
> "On the other hand, if the prevailing notions are that knowledge falls into distinctive categories – that learners should principally be the receivers of the knowledge of others; that they should be capable reproducers of this knowledge; and that this should be measurable by standardised procedures – then it is likely that the impetus will be towards employing curriculum-specific software (where it exists) which will allow for a more efficient realisation of these ends" (Groundwater-Smith, 1987).

There is also a pronounced trend in some countries towards open-ended software which is not subject/topic-specific but is used as an opportunity to create environments in which students can learn. *Flowers of Crystal* (United Kingdom), for example, is a fantasy world adventure game which is used very successfully in a number of countries in project work in a variety of subject areas, such as language development and creative writing, mathematics, science, history, geography, art, drama and music.

An advanced software design which could have considerable impact on classroom teaching is hypermedia. Because their storage of information is non-linear and they provide access to a complex web of text, graphics, images and sound linked through associations, hypermedia systems possibly make computers more compatible with human cognitive processes. For example, a Hypercard system on the Apple Macintosh linked to a laser videodisc containing images and videos of the National Gallery of Art of Washington allows the user to explore the gallery and its treasures along a number of paths. He can browse randomly as the casual visitor might, or he can look at the work of particular artists, periods of art or styles of art, or he can look at paintings representing particular subjects. He can transfer from one exploration path to another through the association of ideas in much the same way as the human mind works. The Domesday Project in the United Kingdom is another such system which allows the user to explore on videodisc material about the people and buildings of the villages, towns and countries of the United Kingdom. A number of such systems are becoming available but are currently financially beyond the reach of most schools.

Chapter 3

SOFTWARE REVIEW AND EVALUATION IN OECD COUNTRIES

Although there has been progress in the range of software available in many countries, teachers are not always aware of what is available to them. Comprehensive and reliable access to information about effective pedagogical practices, whether in the form of software packages or of examples of "good teaching" using the new information technologies across the curriculum, is not readily available to teachers. Teachers seeking software consequently face a daunting task in making responsible selections. The large quantity of published software and the large number of suppliers who would have to be contacted make it virtually impossible for individual teachers, unaided, to identify what software is available.

A number of OECD countries have recognised the necessity of providing teachers with information on the use of the information technologies and have developed means of making it available. In many countries the development of different types of microcomputer-based educational software, the volume and dubious quality of much of the available software, and the needs of teachers for information have created the perceived need for a range of activities specifically related to the reviewing and evaluation of educational software.

Reviews and evaluations can be invaluable since they often reflect the classroom experience of teachers who have used the software under consideration, or the experience and findings of experts in the subject area or in the use of educational software. The professional journals of teachers' associations are particularly valuable in this respect. Commercially published magazines which usually rely heavily on their advertising revenue, on the other hand, are sometimes less valuable since the editors of such magazines are seldom willing to risk alienating their advertisers by publishing negative reviews or to include reviews of products for which they do not carry advertisements.

A significant number of software clearinghouses or agencies have been set up by education authorities or independent non-profit bodies such as universities in order to review and evaluate educational software. Their functions and role vary considerably, reflecting the varying conditions and situations in which they were established. Many of them have as functions providing information to help teachers select software and conducting reviews and evaluations of software. Many maintain an information database in the print and/or electronic medium in order to help teachers.

Activities related to software review and evaluation agencies and the mechanisms for the dissemination of information about software in a number of OECD countries are described in the following sections. The chapter concludes with a discussion of a number of issues directly related to these activities.

AUSTRALIA

Mechanisms for the production and distribution of software reviews have been set up in Australia by all the state education departments at various times but not all have maintained continuity. The activities of the Queensland Department of Education are described below as an example of a state clearinghouse. At the national level, the Commonwealth Curriculum Development Centre set up a National Software Co-ordination Unit at the beginning of 1987. A project at one of the Australian universities is also described.

Queensland Department of Education

As part of its Computer Education Program, the Queensland Department of Education has set up over the past five years an extensive network of regional consultants who work closely with networks of schools within the regions. Much of the work of the consultants is in the area of the curriculum application of software, providing support to the teachers within their regions. An important aspect of their activities has been to conduct so-called "productivity seminars". These are seminars for teachers, who, with the assistance of the consultants, curriculum specialists and support staff, plan and write teaching notes describing the use of particular software packages. In many instances the teaching notes have been distributed to other teachers in the region. The experiences and information gained at these seminars and other regional activities are shared with other teachers through the networks of schools.

The *Software Users Guide to Available Resources* (SUGAR) began publishing reviews of software in 1984. These are distributed to all schools in Queensland and to computer education resource centres in the rest of Australia. SUGAR has established a respected reputation for itself in the field. It emphasizes the view that computers and software are resources to enhance teaching and learning and that reviewers should be teachers experienced in using software in the curriculum.

Software review is conducted by the branch of the Education Department which is responsible for the evaluation of educational resources in all media, thus resulting in an integrated approach to resource selection. Software is obtained for review from the major commercial suppliers of educational software in Australia, some of the education systems, and overseas when necessary. After an initial scan of the package, the editor of SUGAR decides on the most appropriate person or persons to review the package. Initially, reviews are a combination of comments from one of the specialist curriculum officers within the Education Department, one of the numerous regional computer consultants or one or more experienced teachers drawn from the background of the networks described above. Overall quality control is exercised by the editor (Blake, 1988).

Initially, reviews were, for the most part, presented in check-list format, with summary comments. This has developed into a format with a heavier emphasis on summary comments, and the checklist format is used as an indicator where appropriate. Reviews from SUGAR are being incorporated into the National Software Review Database described below.

National Software Co-ordination Unit (NSCU)

The Commonwealth Curriculum Development Centre within the Department of Employment, Education and Training established the National Software Co-ordination Unit

(NSCU) project in 1987 to provide information nationally about software and computer-related learning materials and to co-ordinate the exchange of information about the development of educational software.

The project arose from the need, perceived since 1983, to co-ordinate national efforts and resources in the area of computers in schools. In particular the concept of a national software clearinghouse was believed to have significant potential for helping education systems and schools to make the best use of educational software resources. The Curriculum Development Centre therefore funded a feasibility study in 1985-86 to consider the issues involved in setting up a National Software Clearinghouse and to try out the use of videotex as a means of disseminating information about software. The outcomes of the study indicated that such a service would be welcomed by schools (Winship, 1986).

The NSCU project has developed a software information database currently available to schools throughout Australia either on-line or through microfiche. The National Software Review Database is delivered through the Australian Schools Catalogue Information Service (ASCIS) using the library cataloguing software DOBIS/LIBIS. ASCIS, a service which originally was set up to provide schools with library cataloguing information, is now evolving from this purely library cataloguing facility to include curriculum review information. The national perspective of the project is maintained by consultation between the NSCU project and the education systems.

The format of records in the database consists of a description and one or more reviews. The description is an objective statement about the content of the software, the hardware and peripherals required, the student level, the curriculum area and the availability of the software in terms of the national distributor. This availability statement also provides information on backup and replacement policies, site licences, etc. The review section consists of reviews prepared by teachers who have used the software in the classroom.

It was announced in October 1988 that the NSCU project would terminate at the end of 1988 and that the National Software Review Database would be maintained by education systems inputting data directly to it.

Curtin University of Technology – Schools Computing On-line Resources (SCOR) Database

The Non-Government Schools Computing Centre, which is located at the Curtin University of Technology (formerly the Western Australian Institute of Technology), is a resource and in-service training centre for teachers. It was originally set up in 1984 as part of the National Computer Education Program to service the non-government schools of Western Australia but now also services government schools (in Australia approximately 28 per cent of students attend private schools or schools of a religious denomination which are not part of the state school system; hence they are known as the non-government schools). The particular emphasis of the Centre has been on the use of the computer across the curriculum. To this end an extensive library of over 1 200 software packages has been built up and programmes of in-service training based on the use of software developed. A basic philosophy of the Centre has been that unless teachers have the opportunity to see and use software, it is most unlikely that they will learn to integrate it into their teaching.

The National Software Clearinghouse Feasibility Study (1985-86) referred to above was conducted at the Centre. It involved setting up a clearinghouse of information about software, training teachers in software review and setting up a videotex database, the *Schools Computing On-line Resources* (SCOR) database, on the mainframes of the University. The database has been maintained since the study to serve two major functions. First, it is the software library catalogue of the software available at the Centre for teachers to preview; second, it contains information and reviews about the majority of educational software packages marketed in Australia. It is accessible through direct dial-in lines to the University and through Austpac, the Australian packet switching network.

SCOR has developed as a general information service for the schools of Western Australia, not just on software but on all aspects of computer education. A recent development has been the transfer of the database to the Hypercard software on the Macintosh microcomputer.

BELGIUM

Dutch-speaking Area

In Dutch-speaking Belgium, a set of criteria for the evaluation of software modelled on the Canadian *Software Evaluation* (Council of Ministers of Education, 1985a) was drawn up on the initiative of the Ministerial Committee for the Effective Integration of Informatics. This list of minimal standards, intended as a guideline for teachers in the evaluation of existing software and for developers in the design of educational software, was distributed in 1985 to all Flemish state schools, the Inspectorate, and the state-supported schools through their representatives in the Ministerial Committee.

A standard form for the description of educational software and an evaluation checklist were also designed by the same committee.

In 1987 the Minister of Education established a national information centre on the new information technologies within the Centre for Media and Information Technology of the Ministry of Education (Dutch-speaking area) with the following functions:

- To act as a central information and documentation point;
- To co-ordinate in-service training and guidance;
- To provide opinions on policy in co-operation with the Ministerial Committee on Education and Information Technology and its specialised working groups;
- To co-ordinate the testing, approval, production and distribution of educational software;
- To set up a regional network for information technology;
- To co-operate in international initiatives connected with education and the new information technologies.

The Centre compiles an inventory of Dutch educational software and co-ordinates the evaluation of the software by groups of teachers and subject and media specialists who examine both the technical and pedagogical aspects of the software. Problems observed during the evaluation are discussed fully with the software author(s) in order to enhance the product. A ministerial committee decides on the validation of the product based on the report of the evaluation groups.

The Centre for Media and Information Technology will publish a first list of validated software in the near future. Software can be obtained from the Centre or can at least be previewed there. It is planned to establish a network of software preview centres in the teacher training schools (Platteeuw, 1988).

French-speaking Area

Five resource centres have been created in conjunction with university departments of education in the French-speaking areas. These OSE (*Ordinateur au Service de l'Education – Computers for Education*) centres are open to teachers and parents for the preview of a considerable number of educational software packages. A comprehensive review instrument has been developed and a working group composed of inspectors, teachers and education specialists has been set up to review elementary level software. Products selected for use in the schools are given a "quality label".

CANADA

In Canada the major developments in the field at the provincial level have taken place in Alberta, British Columbia, Ontario and Quebec. The activities of the Alberta Education Clearinghouse are described below as an example of a provincial clearinghouse. At the national level the Council for the Ministers of Education of Canada has set up a national database project into which the provinces feed their reviews. An interesting project at one of the Canadian universities is also described.

Alberta Education Clearinghouse

Alberta Education has a software clearinghouse which is recognised throughout the United States and Canada as a highly successful reviewing body at the state or provincial level. Over the period 1982-85 while the province invested over C$30 million in hardware in the schools, the Software Clearinghouse had an annual budget of C$500 000. This has since been reduced. The Clearinghouse has a well developed process of evaluating software, including an *Evaluator's Guide* for microcomputer software in general and others for Accounting and Word Processing courseware, and has published a number of catalogues of reviews. It has set itself a very high standard and it is very interesting to see some of the packages it rejects and the reasons for the rejection.

One problem the Alberta Clearinghouse saw in its early days was the danger of being totally submerged by the sheer volume of software becoming available. It attempted to review software for all curricular programs. It was in touch with some 700 suppliers and at one stage tried to evaluate some 1 000 packages annually. In order to speed up the process, a screening instrument was designed to enable the staff of the clearinghouse to screen out materials that are deficient in major characteristics, for example: the subject matter is not part of the Alberta curriculum, the program does not work as described, the content is inaccurate, question randomisation is ineffective.

More recently, it is reported (Pace, 1988), the Clearinghouse has moved to a needs-driven model. This is because it is considered there is now a flood of good software on the market and there are no longer the resources to evaluate everything. As a curriculum comes under review or development, a call for software in that area goes out to publishers/developers. After this call, software in that area may not be reviewed again for the program until its next revision.

Teachers are used as reviewers and are paid. All reviewers go through an intensive two-day training course during which they evaluate a number of set packages which have been chosen to illustrate, for example, problems in content, problems in management system, etc. Their evaluations are marked. At the end of the training course a test is given that is to be completed in two weeks. This too is marked. The average score achieved is about 65 to 75 per cent. There are few failures of the test mainly because there is a certain amount of natural selection and dropout. Alberta has trained some 200 reviewers in this way.

Alberta Education uses a three-stage process for the evaluation of software. First of all, materials are screened for curriculum congruence and instructional potential. The best available reviewer teachers are used for this stage. If found appropriate, the courseware is then reviewed independently by at least three reviewers each of whom completes an eight page evaluation. These second-stage reports are then synthesised into a two-page report and successful materials advance to the final stage in which they are assessed by the Curriculum Design, Curriculum Support and Languages Services branches which make a decision on the materials status.

Packages are given status as basic, recommended and supplementary, as defined below:

- *Basic Learning Resources*, which are those "learning resources approved by the Alberta Education as the most appropriate for meeting the majority of goals and objectives for courses, or substantial components of courses, outlined in provincial Programs of Study; and, those productivity software programs (e.g. word processors, spreadsheets, databases, integrated programs) approved by Alberta Education that can be used to achieve important objectives across two or more grade levels, subject areas or programs";
- *Recommended Learning Resources*, which are those "learning resources approved by Alberta Education because they complement Basic Learning Resources by making an important contribution to the attainment of one or more of the major goals of courses outlined in provincial Programs of Study";
- *Supplementary Learning Resources*, which are those "learning resources identified by teachers, school boards or Alberta Education to support courses outlined in provincial Programs of Study by reinforcing or enriching the learning experience";
- Rejection indicates that the program has little, if anything, to contribute to achieving the provincial Programs of Study.

Alberta Education participates in the Educational Software Evaluation Consortium and uses the "Educational Software Preview Guide" to narrow down the selection of software to be reviewed. Packages which have been unfavourably reviewed by other reputable agencies are ignored. Alberta Education also contributes to the Council of Ministers of Education Canada Database described below.

Council of Ministers of Education, Canada, Database

The Database for Educational Software, developed by the Council of Ministers of Education Canada (CMEC) aims to provide educators with descriptive and evaluative information on microcomputer software currently available in Canada.

The project grew out of the expressed need of Canadian educators for more information relating to instructional technology and in particular relating to computer use. The decision to establish a national database followed three years of negotiation and exploration of standard methods of indexing and cataloguing information on educational software. The system became operational in early 1986.

The database currently contains information on about 1 600 software packages such as product descriptions, costs, applications, hardware requirements, contents, evaluation information, etc. The evaluative information consists of an analysis of pedagogical content, instructional format and technical design. An evaluator's recommendation for the package's use within the evaluating province is also provided.

User access is provided in both official languages, French and English. The database has been structured with the aim of making it easily accessible for relatively unsophisticated users in schools and other related educational institutions. To facilitate searches of the database, a bilingual thesaurus of descriptors has been developed. Database access is on a "user pays" basis (C$25 an hour, including communication charges). The Council of Ministers of Education, Canada, has underwritten the cost of establishing and maintaining the database.

It appeared obvious to the task force in charge of establishing the database that a common evaluation system was necessary in order to ensure reliability and to facilitate exchange of information.

Software evaluation instruments used by the provinces were examined, and drawing heavily on the work done by Alberta Education, a standard set of 19 criteria for evaluating educational software was defined and published in both English and French (Council of Ministers of Education Canada, 1985a).

> "The logistics of standardized data collection involving ten provinces and two territories and done in two languages present a formidable challenge. Each province and territory is at a different stage in software data collection and evaluation within its own jurisdiction. The procedures established for this database may accelerate existing practices in addition to providing a valuable source of information. Ultimately, the crucial factors in making this a viable project have been the endorsement by all the Ministers of Education and the commitment on the part of all the provincial ministries to make it work" (Rich and Jafri, 1985).

The database has been operational only since 1986, but based on this experience, the record structure has already been streamlined better to meet user needs. Ewing reports that although the database is accessible to online users, the majority of users prefer to have the contents of the database available in print format.

> "Factors influencing this preference may include online connect charges (although extremely modest by online industry standards), the need for specialised hardware and software, and the significant amount of time it takes to learn how to perform an online search".

Ten subsets of the database have been reproduced in print (Ewing, 1988).

The database does not represent a complete listing of packages currently available in Canada since each province decides which pieces of commercially available software it will evaluate and submit for inclusion in the database. Some provinces send information only on software that has been funded by the province and developed to their hardware and curriculum standards. Smaller provinces do not have the resources to create evaluative records, which, according to some provinces, cost between $600 and $700 (Canadian) to produce (Ewing, 1988).

Moreover, evaluating software in isolation from the concerns of curriculum fit has proved to be a difficult process. Since each province defines its own curriculum, curriculum-fit information is seen as not being a suitable information element in a national database. Each province still has to perform its own analysis of curriculum fit. Because of this, it has been suggested that the role of the database should be to give a brief indication of whether or not a piece of software deserves consideration rather than to provide in-depth evaluations (Ewing, 1988).

A trend which is evident elsewhere in the world has emerged in Canada. As classroom computers become less of a novelty, educators are increasingly using integrated applications software that enables the computer to be used as a tool for a variety of tasks and problems as well as for using subject-specific software. The use of desktop publishing, word processing, spreadsheets and database management packages is becoming more common in Canada. New evaluative criteria are therefore being found necessary for judging the use of applications software packages in the classroom (Ewing, 1988).

Despite these early teething problems, the provinces have reacted positively to what has been achieved so far and have strongly endorsed the continuation of the project (Rich, 1988).

York University On-line Service

This service has arisen out of a co-operative project between the York University Faculty of Education and IBM Canada. It is a public data service offered to teachers, schools and other educational institutions consisting of a number of databases, including: comprehensive listings of information on over 12 000 elementary and secondary school educational software packages for all commonly used types of microcomputers; software evaluations conducted by the York Faculty of Education using criteria developed by the Faculty (see Owston, 1987, for further details) and by other individuals and institutions; names and addresses of software producers and distributors; a directory of information on programs and services of interest to special education teachers.

The service also includes an electronic bulletin board that allows Canadian educators to exchange information on educational software or on the contents of any of the databases, and a facility allowing educators to submit their own software evaluations for possible inclusion in the database. No charge is made for use of the service by non-profit educational users.

FRANCE

In France principal responsibility for software assessment lies with the Ministry of Education, but initiatives have been taken by various institutions, such as: at the national level, CAMIF, a teachers' co-operative; and at the regional level, CLEO (*Centre Lorrain d'Enseignement Assisté par Ordinateur*), a centre for computer-aided instruction. CESTA (*Centre d'Etudes des Systèmes et Technologies Avancées*), a government-supported centre for advanced technologies, which ended its activities in 1988, is important for its initiative in creating a software library.

The National Ministry of Education

Since the Ministry has centralised control over curricula and teacher training, it has played a major role in designing and providing educational software. The following overview of past developments is useful in understanding the present situation.

When the first secondary schools were equipped with computers in 1970, the INRP (*Institut National de Recherche Pédagogique* – National Educational Research Institute) took responsibility for the training of teachers in the use of computer technology and for the *control* of educational software developed by the teachers participating in the 58-school pilot programme. A software bank listing 400 items, and covering a wide range of subject areas was set up by the INRP. The software was sent to the schools upon request, free of charge.

When generalised equipping of the schools began in 1981, the CNDP (*Centre National de Documentation Pédagogique* – National Educational Resource Centre), took over the evaluation and distribution of educational software produced by teachers. The CNDP software library was regularly updated, expanded and software distributed to the schools with equipment.

The *Informatique Pour Tous* (Informatics for All) programme was introduced in 1985 to accelerate the equipping of schools and teacher training. Along with the hardware supplied to schools (from elementary to upper secondary), each school received free of charge a "suitcase" of pre-selected software. Schools could acquire a certain number of additional software products from among the 700 items listed in the National Ministry of Education's software catalogue.

This *Catalogue des Logiciels* provided, for the most part, a factual description of software developed by, among others, the CNDP and participating educators. It was not intended as an endorsement of the products listed. The Minister of Education stated in the preface:

> "The richness and diversity of this catalogue are the fruit and the illustration of the knowledge acquired by teachers... However, inclusion in the catalogue does not mean that the Ministry of Education gives a quality label to the software...".

The 1986 *Plan National Informatique* (National Informatics Programme) modified existing hardware and teacher training policies, the major change being in the area of software evaluation and production. First, it was decided that the General Inspectorate of the Ministry of Education should review the 700 software packages available to teachers. Their unpublished report was extremely critical of many of them. It was therefore decided to favour software which provides *access to information and knowledge*, that is, simulations and databases, and to create an educational software task force (*Commission des Logiciels Educatifs*) composed of representatives of the Ministry of Education's Pedagogical Directorates and of the General Inspectorate. The group, chaired by the General Inspectorate, is responsible for selecting the best *pedagogical scenarios* submitted in an annual national competition open to all teachers. The prize-winning scenarios, programmed and commercialised by private publishing houses, bear the National Education seal of approval.

In order to facilitate the purchase of expensive software products by schools – for example, authoring languages, word processors, simulations and databases – the principle of "mixed licenses" has been developed. By signing contracts with private publishers, the Ministry of Education obtains the right to use the software for a fixed fee, and the publishers sell it to schools at approximately 10 per cent of market price. This strategy aims also to decrease unauthorised duplication of the software.

With this change in policy, the CNDP ended its software publishing activities in 1987 but it continues to serve as a clearinghouse; its products are still available to schools and can be consulted through the electronic database LOGIDOC on TELETEL. Its final catalogue listed 160 selected packages. The Director states in the preface:

> "To choose educational software is a difficult task... Designed by teachers and carefully selected, these software packages are quality products".

One hundred and ten local or regional resource centres linked to the CRDP (*Centre Régional de Documentation Pédagogique*) maintain software libraries. Examples of these can be found in Marseille, Toulouse and Bordeaux. The Nancy-Metz CRDP Centre for Computer Resources has published the *Fenêtre Active* (Active Window) series written by teachers who have used software in their classes. The objective of the series is the assessment of the integral classroom use of educational software.

Because of the centralisation of the French education system, the Ministry continues to play a determining role in software review and evaluation. However, the present trend is to develop the private as well as the public sector. The General Inspectorate has clearly stated that teachers should be in the same position of choice as they are with text books and that the best it can do is to provide information about software products sold by private publishing houses.

CAMIF

The CAMIF is a co-operative open to teachers and other Ministry of Education employees. In 1986 the organisation set up a committee (*Commission des Logiciels Educatifs*) composed exclusively of teachers to examine the quality of the educational software listed in its catalogues. The stated goal is not to monitor technical qualities, nor to judge the degree of conformity of the products to pre-established norms, but rather to give potential buyers the opinion of a number of their colleagues. The evaluation of the software is based on actual use, either by individual users or in the classroom. The committee has overseen the testing by teaching teams of nearly 400 software packages. Of these, 35 per cent are tool software such as word processors and spreadsheets used for educational purposes. The assessments appear in the CAMIF catalogues published in print form and may be accessed electronically through the TELETEL videotex system. The packages which have been tested are identified and their entries contain a listing of strong and weak points, as well as the usual descriptive information. They are also listed in a comparative chart which indicates ratings on a five-point scale on various criteria in four major areas – pedagogical quality, interest shown by the user, ease of use and flexibility of use.

The Lorraine Computer-assisted Instruction Centre (CLEO)

CLEO is an independent regional association founded in 1986 to promote computer-assisted instruction particularly in the Lorraine region (northeast of France). The association is made up of various public and private entities as well as institutions of higher education and research. Its activities fall into four areas: documentation, teacher training, software production and research.

About 700 software packages in 25 subject areas may be previewed in the CLEO software library. The catalogue prepared by the library is available in hard copy, but may also be consulted through the French videotex service, TELETEL.

The Centre for the Study of Systems and Advanced Technologies (CESTA)

During the 1982 Versailles Summit of the Seven Heads of State and Government and the European Communities, it was decided to establish a working group on *Technology Growth and Employment*. This Group presented 18 international co-operation programmes at the 1983 Williamsburg Summit. Among them was *New Technologies Applied to Education, Professional Training and Culture*, known as ANTEM. This programme was drawn up by France and Canada, with the participation of England, Italy and the European Communities as partners, and was placed under the responsibility of CESTA, a French government-supported institution.

One of the major activities of ANTEM was the creation in 1983 of an educational software library in Paris. The *Didacthèque*, as it was called, containing some 1 500 education and training software packages, served as a preview centre for teachers. A directory of available educational software, also accessible via the French videotex service, TELETEL, was issued each year. A detailed description, plus pedagogical or technical comments on a number of software packages, was provided as an aide to teachers wishing to preview the software. Although the 1987 directory listed more than 1 000 products for primary and secondary education, the Director stated clearly in the preface that the reader: " ...is the master of his choice", that "the worst rubs shoulders with the best" and that "only those who persevere after their initial disappointment" will discovery interesting products.

About 8 000 visitors had used the services of the *Didacthèque* and 700 had attended seminars on technology-based training and education when the CESTA was closed in January 1988. The *Didacthèque* software collection has been transferred to the Villette Science and Industry Pavillon in Paris (Cité des Sciences et de l'Industrie de la Villette).

GERMANY

In Germany the use of the computer across the curriculum is limited, computer education having been introduced into schools mainly in the form of *learning about* rather than *learning with* the computer. In the first instance, an informatics course was introduced for students aged 16 to 18. Currently syllabi are being developed to produce units for computer literacy for all students at the age of 13. There is practically no use of computers in the first years of education.

It is recognised that the quality of courseware available for use in general education between the ages of 13 and 18 requires sustained improvement. A nationwide project, *Qualification of Authors for Educational Software*, supported by several of the *Länder* (which are autonomous in matters of education), a number of institutes, research groups and publishing houses, has therefore been started to attempt to remedy the situation. The aim is not to build up a centre for the production of educational software but to establish an infrastructure for courseware development. The project involves the setting up of groups of software authors who will adapt or rewrite and test existing foreign software for use in the German school situation. The software produced will be evaluated and revised as necessary before publication. The project is co-ordinated by the National Institute for Science Education (IPN) (Bosler, 1988).

ITALY

A National Plan for Informatics in Schools was started by the Ministry of Education in 1985. The Plan defines the cultural and conceptual aspects of Informatics and the use of software as a learning tool across the curriculum. Although at the present time the Ministry of Education has not promoted any systematic activity for the review and evaluation of educational software, a well established activity in this field is carried on by the *Istituto Tecnologie Didattiche* of the Italian National Research Council.

The Institute is a research institute that has operated in Genoa since 1970. In 1985 the Institute established the BSD, or *Biblioteca del Software Didattico* (Educational Software Library), an initiative aimed at providing a national point of reference in the field of educational software. The BSD's services are oriented for the most part, although not exclusively, to the schools. It is also intended as a resource for research in the field of educational technology. It collects, reviews and evaluates Italian and foreign software and disseminates information about it. It is the only initiative of this kind carried on by a public institution in Italy.

The BSD has agreements with all the Italian publishers and systematically receives all newly published software. Foreign software, most of which is in English, is also collected. At present the collection contains about 1 200 packages, 60 per cent of which are in Italian.

Software is reviewed and classified according to a predefined format and the information incorporated into a database. The information included in the database contains only objective data both of a technical and pedagogical nature, including a summary of the content of the package and a description of the educational strategy. Reviewing is done by teachers as a part-time activity.

BSD offers a public consultation service. People can query the database and try out the software that interests them. Technical and educational assistance is provided to the public in accessing the computers and selecting the software most suited to their needs. Remote consultation of the database is also available, including access through the international network EARN (European Academic Research Network).

BSD also organises bi-monthly two-day seminars on educational software for specific subject areas and school levels. Average attendance at the seminars is 30.

The various activities related to software review and evaluation are oriented towards promoting the development of a culture of educational software and of autonomous skills of evaluation among teachers rather than towards giving each package a quality score. To this end the BSD is now publishing a book of examples of analyses and evaluations of educational software packages made by qualified teachers and experts. The book will contain analyses of about 150 packages covering all disciplines and school levels.

JAPAN

In Japan, most software being used in schools has been written by teachers or by university researchers in co-operation with teachers. In addition a number of software houses have recently begun to develop educational software (Shafroth & Sakamoto, 1986).

The Ministry of Education has commissioned some boards of education and research groups to develop models of high quality software for teaching. It also set up in 1988 a Center for Research on Educational Software that has three areas of activity. The first is to collect, review, evaluate, and, if necessary, to improve software developed in schools and other educational institutions and to disseminate information about it. The second is to promote the development of educational software by holding seminars, publishing a magazine on educational software and practical research, providing information on examples of classroom practice and advising schools and the research groups on R&D in educational software. The third area of activity is Research and Development, including annual surveys on specific themes related to the educational use of computers and on research into an educational materials database.

Although there is no firm standard for the evaluation of educational software at present, in 1985 the Ministry of Education published basic guidelines for developing good educational software which are used by teachers as a reference in selecting and evaluating appropriate software (A Manual for Development of Educational Software, 1985).

THE NETHERLANDS

As part of its Informatics Stimulation Plan, the Netherlands Ministry of Education has established a project called the Software and Courseware Evaluation Centre, the Netherlands (SCEN), which is operated and managed by the Educational Computing Consortium B.V. (ECC).

SCEN has two major goals: first, to provide educational organisations with information which will enable them to find and make responsible choices when buying software and, second, to determine the criteria for good educational software. With regard to the first, ECC is setting up the ECC database of Literature and Educational Software (ECCLES), which when operational will contain descriptions and evaluations of over 2 000 software and courseware products available on the Dutch market; descriptions of some 6 000 documents concerning the application of the information technologies to education and training both in the Netherlands and abroad; and descriptions of all major information technology projects being conducted in lower and secondary education in the Netherlands.

With regard to the second goal, ECC has developed standard procedures for the evaluation of educational software and has carried out a large number of evaluations by means of a network of over 350 subject specialists and experienced teachers. A four-stage method of formative evaluation has also been developed for use during the different stages of the development process of educational software products (van Muylwijk, 1988).

NEW ZEALAND

The New Zealand Government has established a Computers in Education Development Unit to support and co-ordinate developments in educational computing. It also funded a major project in 1986 and 1987 known as the "Exploratory Studies in Educational Computing" to evaluate educational computing in New Zealand. The project funded 15 studies involving a total of 56 kindergartens, primary, intermediate, and secondary schools. The studies were well funded and formally evaluated by the New Zealand Council for Educational Research. Although the detailed report of the Research Council is not yet available, the general conclusion of the evaluation appears to be very favourable. The studies have provided models that other schools can draw on for classroom computer activities which appear to be potentially the most useful. As a result a second phase of studies has already been embarked upon (New Zealand Department of Education, 1988).

With regard to software review, the Department of Education purchases promising software and refers it to selected experienced teachers for review and evaluation. The Computers in Education Development Unit has published a review form for this purpose, and reviews are published in the Unit's Newsletter. The Unit has also entered into an arrangement whereby software reviews from educational computing centres in Australia are reprinted and distributed to schools (New Zealand Department of Education, 1988).

SWEDEN

In response to teacher demand for information, the Educational Software Group of the Ministry of Education has tested various ways of evaluating software, with the aim of compiling a document which teachers can use in making their own assessments of software.

The experiences of Canada and Norway have been drawn upon in this respect. The Group has also taken part in work initiated by the Nordic Council of Ministers to identify software, publish national software catalogues and create a database which teachers will be able to access.

In conjunction with the work of the Educational Software Group, state grants have been used to set up a number of resource centres aimed at providing teachers with expert assistance and information about software. Of particular interest is the software lending library which was set up at Karlstad University College as a centre of information on software applications. The software library is housed in the University College Library. As the lending statistics reveal, there was initially a pent-up need for the type of information provided by the library, but its services have not been in great demand on a continuing basis. This could be because the range of software intended as teaching aids is not sufficiently comprehensive or of high enough quality to interest the teachers.

THE UNITED KINGDOM

ENGLAND, WALES AND NORTHERN IRELAND

In 1988, a new strategy for information technology in schools was launched to build upon the earlier work of the Microelectronics in Education Programme (MEP). In the area of software, MEP's emphasis was towards the development of software across the curriculum. The aim of the new strategy is to increase the extent and effectiveness of school use of information technology to enhance teaching and learning for pupils of all ages and abilities across the school curriculum.

An Information Technology in Schools Unit, set up in the Department of Education and Science (DES) to carry forward the strategy, is to commission a major policy-oriented research study to provide firm and consistent evidence of the effectiveness of the uses of information technology as a teaching and learning resource. The Unit is also investigating the extent to which software and accompanying materials are available to meet the requirements of National Curriculum subjects and the attainment targets to be set for them.

Much of the reviewing and evaluation of software in England and Wales is conducted by teachers' subject and phase associations which review the software that becomes available in their own subject or phase disciplines. They distribute their reviews to members through their normal information channels. For example, associations such as the Geographical Association and the Microcomputers and Primary Education (MAPE) review software packages in their respective areas of interest and publish their reviews in *Teaching Geography* in the case of the former, and in *Microscope* in the case of the latter. There are currently no provisions for the reviewing or evaluating of software on a centralised basis (Thompson, 1988).

A number of publications which are of considerable interest in the field have been produced. They include: *Guide to Evaluating Methods – A Manual for Microtechnology Innovation*, published by the National Extension College; a resource pack, *Signposts for Evaluating*, published by the Council for Educational Technology, and *Educational Software – A Creator's Handbook*, edited by Alexander and Blanchard and published by the MEP. A teacher training pack for primary and secondary teachers, *Educational Software*, was also produced by the Open University's Micros in Schools Project.

Among the major agencies in the United Kingdom are the National Council for Educational Technology (NCET), the National Educational Resources Information Service (NERIS) and the Centre for Evaluation of Information Technology in Education (CITE).

National Council for Educational Technology (Microelectronics Education Support Unit)

The National Council for Educational Technology (NCET) was established in April 1988 through the merger of the former Council for Educational Technology (CET) and Microelectronics Education Support Unit (MESU). The merger is intended to strengthen support for education and training providers, particularly in the context of the new strategy for information technology in schools. The MESU function is to promote and spread good practice in using the new technologies in education. Its objectives are:

- To improve the exchange of ideas and information;
- To consider ways in which change in schools can be supported;
- To support those whose tasks include the further spread of information technology across the curriculum;
- To illustrate and promote positive images of what is possible and desirable in using new technologies in schools;
- And to provide a national forum for discussion and activity to tackle common issues.

With regard to the first objective, the provision of information, the MESU maintains an information library which may be accessed by the educational authorities and the institutions providing teacher training.

National Educational Resources Information Service (NERIS)

The National Educational Resources Information Service (NERIS) database is an on-line educational database of curriculum materials and information. It was set up in 1986 by the United Kingdom Department of Trade and Industry with initial funding of £750 000 for a little over two years. Since mid-1988 it has been established as an independent educational trust. Its objectives are, first, to develop a database system which will enable teachers to locate up-to-date and relevant learning materials and curriculum information that is scattered throughout the country; second, to create a system which can be accessed with equal ease and satisfaction by users having little knowledge of on-line retrieval systems and by experts in such systems; third, to deliver teaching materials in their entirety directly to schools by electronic means.

The database has been operational since early 1987. It is held on the mainframes of the Open University and is accessible through the public videotex service, Prestel, The Times Network Systems (TTNS) and the British Telecom private network. Access to NERIS is at no additional cost to schools, access via Prestel and TTNS being covered by the annual educational subscription to these services, and access via the Telecom private network being paid for by the Department of Trade and Industry. Since most schools in the United Kingdom have modems, they can have access to the database at the cost of a local telephone call. A CD-ROM version is also being trialled.

Intended users are seen as teachers, students, resource centres, subject specialists, curriculum advisers, support staff and higher education institutions. Usage has shown a steady and very satisfactory growth (Taylor, 1988). Easy-to-follow user guides have been written, together with tutorial software for the BBC Acorn microcomputer.

The database contains information about "learning resources" in the broad sense. This includes reviews and case studies of the use of computer software and other resources, such as visual, printed, audio-visual, production, and information-handling resources. By February

1988, the database contained information about some 10 000 items of curriculum materials, including in many cases the materials themselves. Users are able to print out both the information and the materials. A typical entry might consist of information about a series of worksheets on a particular topic, for example, *Fish Farming and Angling as Extra Sources of Income*, and the worksheets themselves. Information on some 2 000 software packages is to be available by mid-1988 (Taylor, 1988). Initially NERIS is focusing on the areas of mathematics, the sciences, social and personal education and geography.

Centre for Evaluation of Information Technology in Education (CITE)

The Centre for Evaluation of Information Technology in Education (CITE) was established in 1985 by the National Foundation for Educational Research (NFER) to identify and investigate criteria for the design, evaluation and curricular exploitation of media, materials and learning environments which use computer-based information technologies. The Centre's major concern has been with techniques for evaluation, particularly of software, and it has evolved a teacher-led action research approach.

SCOTLAND

Regarding the provision of information and software preview centres, the Scottish Education Department's report on computers in schools states the following:

Resource centres where teachers can preview software have been set up in nine education authorities. The extent to which these have been stocked depends upon the initiatives of individual advisers and the availability of funds. Whilst the effectiveness of preview centres and software libraries in offering a provision to all secondary schools is widely variable, there have been some notable successes, and the potential of such a facility is clear.

The extent of use of these preview facilities is unquestionably related to ease of access. The problems of provision in the more dispersed areas of population have not been resolved, but some interesting initiatives have been tried. One authority has experimented with the mounting of software descriptors on a local viewdata system, whilst another has mounted descriptors and evaluations of software on The Times Network Systems (TTNS), which also enables teachers to lodge preview requests. This same authority was considering the possibility of some secondary schools acting as resource centres for themselves and their associated primary schools. Another authority has issued a database file of their software library to every secondary school, so that teachers can easily extract package titles relevant to their subject area, then request the packages through TTNS. Postal and courier delivery of software is used to some extent in all authorities. At least one authority is investigating the possibility of involving their schools' library service in the lending of software.

In most authorities, advisers and staff tutors from a range of subjects have been instrumental in publicising and disseminating information on software, sometimes through bulletins and newsletters. This has been particularly effective in an authority where a regularly published newsletter contains teachers' evaluative descriptions of classroom-trialled packages. However, the extent to which this has occurred has depended upon the initiatives and interests of individual advisers, rather than on any broad policy thrust. Most advisers and tutors have software funds which they use to augment the authority or divisional libraries and to provide packages for evaluation in schools. Many advisers convene very productive teacher working groups within which software is specified, produced, identified and evaluated (Scottish Education Department, 1987).

THE UNITED STATES

The range of activities in the United States in the field of software review and evaluation is extensive and extremely varied. An analysis of the state of the art shows that in the United States, state departments of education have several ways of helping their school districts evaluate software and that no two states are exactly alike in the evaluation materials and methods that they use. Some adopt evaluation materials from the Educational Products Information Exchange (EPIE) Institute or from Microcomputer Software Information for Teachers (MicroSIFT), a division of the Northwest Regional Educational Laboratory. Some have trained teachers in the skills of reviewing software and have set up their own software clearinghouses, often with the assistance of EPIE or MicroSIFT. Some have published review forms which they encourage teachers to use to review software themselves. Some states publish their own reviews or lists of recommended or approved software. Some use a combination of systems.

In addition to these state-sponsored aids, United States teachers also have available to them a number of other sources of information about software. A number of professional associations for teachers publish on a regular basis software reviews and related information in their journals. These include the National Council of Teachers of Mathematics (NCTM), the National Science Teachers Association (NSTA), the National Education Association (NEA) and the International Council for Computers in Education (ICCE).

The latter organisation is particularly important as the international organisation to which many of the national associations of professional computer educators in other countries are affiliated. It publishes *The Computing Teacher*, which is intended for persons interested in the instructional use of computers. The journal emphasizes not just teaching about computers but also teaching using computers, teacher education and the impact of computers on curricula. It has a regular software review section and a valuable section entitled *Research Windows*, which contains summaries of recent research findings. From time to time, the ICCE also produces policy statements on issues such as software copyright, for example, and the criteria for identifying software resource centres.

CONDUIT is another organisation, which, although aimed primarily at the higher education sector, is also relevant to the lower levels of education. It originated in the early 1970s as a consortium of a number of universities – North Carolina, Dartmouth, Iowa and Texas at Austin – from which it took its name, with the aim of providing a mechanism for the evaluation and publication of educational software written by academics. It has acted as a significant impetus for research and as a clearinghouse for software both for mainframes and for microcomputers.

A number of projects and organisations have also been established in the United States to cater for the needs of Special Educators. These include the Special Education Software Center, which is funded by the United States Department of Education (Special Education Programs) and is a clearinghouse for information about software and resources for special education, and the Special Education Computer Technology On-line Resource (SECTOR) project at the Utah State University, which has set up processes for reviewing software for special education needs.

A number of publications are available to teachers. EPIE publishes *The Educational Software Selector* (TESS), which is a catalogue of information and reviews on over 10 000 packages and a guide for parents to the best educational software for use in the home. The ICCE publishes an annual *Educational Software Preview Guide*, a list of those packages which have been most favourably reviewed by members of the Educational Software Evaluation Consortium of United States and Canadian agencies. Other publications available to teachers have included *Only the Best* and the *Digest of Software Reviews*. *Only the Best*, of which three editions have been published, attempts to identify the software most highly rated by the major software evaluation agencies in North America. The *Digest of Software Reviews*, which combined with *Software Reviews on File* in 1986, was a digest of published software reviews, as the title indicates. Also available are the six *Technology in the Curriculum Resource Guides* published by the California State Department of Education Office of Educational Technology described below.

Microcomputer manufacturers have also published curriculum guides and catalogues of software for use on their equipment. Worth mentioning is the series of K-12 curriculum guides published by Apple Computer in 1987 and 1988 for science, mathematics, reading, writing and the language arts, health education, life science and early language. They provide correlational matrices linking, in the view of the editors, the best available software for use on Apple computers with defined curriculum objectives. A number of educationalists, including staff of MicroSIFT, have collaborated in the publications.

A number of on-line databases have been or are available to teachers. They include the RICE database established by MicroSIFT and the TECC set up by the Texas Education Computing Co-operative, both originally on the BRS Information Service; the TESS database created by EPIE, which until recently has been available on the CompuServe on-line service, and the database made available on the Florida Information Resource Network (FIRN) by the Florida Center for Instructional Computing (FCIC).

As can be seen from this brief summary, the activities in the field of software evaluation are too numerous and varied to be described in a report of this nature. The following section therefore includes descriptions of the activities of EPIE and MicroSIFT, the pioneers in the field, as examples of national level organisations, the mechanisms for software evaluation in California and in Florida as examples of the activities at the state level and the activities of the Educational Software Evaluation Consortium and the SEED co-operative of the Southeastern states as examples of co-operation among a number of agencies.

Microcomputer Software Information for Teachers (MicroSIFT)

MicroSIFT was the first attempt of its kind at setting up a clearinghouse for information about microcomputer-based educational applications. It was established in 1979 with federal funding at the Northwest Regional Educational Laboratory, Oregon.

In MicroSIFT's first year of operation SIFTNET, a network of reviewers at some 20 sites across the United States which review and evaluate software, was set up. The network includes school districts, regional service centres, state departments and state consortia, some of whose staff is assigned to supporting the instructional computing activities of schools in their areas. Many of the SIFTNET sites formed the basis of state reviewing bodies which were set up later. It is thanks to MicroSIFT's pioneering work that the need for review and evaluation of software has been clearly established and that a number of other agencies have been set up.

A primary activity has been the development of an evaluation process and instruments uniquely suited to microcomputer-based instructional materials. This focus has resulted in the *Evaluator's Guide for Microcomputer-based Instructional Packages*, the publication and dissemination of some 500 Courseware Evaluation Reports and the development of an on-line database.

This latter is the "Resources in Computer Education" (RICE) database. It contains over 3 500 citations, including the MicroSIFT reviews, together with information on some 2 000 microcomputer courseware items. Included are bibliographic citations for packages that have been evaluated by other agencies or publications. The database has been accessible through the BRS service using the STAIRS retrieval software.

In its literature MicroSIFT points out that the evaluations resulting from this process are professional opinions based on the experience and expertise of the evaluators and not necessarily on observation of student use of the packages. Although some evaluations do include student use, the evaluators are volunteers and their time does not always allow for extensive student involvement. Also, a package may be evaluated at a point in the school year not in conjunction with the time the topic is studied.

The assessment of MicroSIFT by Olds (1983) is appropriate:

> "MicroSIFT, as the first attempt of its kind, broke new ground and illuminated problems yet to be solved: first, evaluation by committee may be a worthwhile process if the committee can hammer out a consensus. But if the committee never resolves differences and the consensus is created by another party, the result may be a very odd stew. Second, while the goal of MicroSIFT's methodology – to attain reliability and credibility by reducing the level of subjectivity in evaluation – is a worthy one, the result does not always make clear distinctions among different programs or differentiate good programs from bad ones. In spite of its wrinkles MicroSIFT has provided educators with one of the first evaluation forms to attempt to collect data in some depth. In addition, the creation of a network of educators interested in evaluating software and sharing their evaluations was valuable in itself, and contributed to the growing body of knowledge about evaluation as a process".

MicroSIFT came to the end of a five-year funding period at the end of 1985. Since then a number of changes have taken place which reflect changes in priorities in the Northwest Region and a reduction of staff resources due to inflation and normal cost increments.

In the first place, both the style and frequency of MicroSIFT's software evaluation reports have changed. Rather than producing a set of individual package reviews based on three teacher reviews each, MicroSIFT now produces reports which are syntheses of available evaluative opinion on sets of packages narrowly defined by application, subject and/or level, for example, *Databases in Secondary Social Studies*. When 30 to 50 packages are available on a given subject, a subject area is defined and the existing reviews on it are examined. These are supplemented with additional reviews by local teachers, where necessary, and ten or more packages which exemplify the best characteristics in the group are identified (Holznagel, 1988).

In the second place, effective January 1, 1988, the RICE database was removed from the BRS information service and installed on a microcomputer in the offices of MicroSIFT. The reasons for the move are: RICE has not been self-supporting from user fees; not many school districts are interested in maintaining and using a subscription to a major on-line system such as BRS; the costs were too high for MicroSIFT's budget; and MicroSIFT was being pressured to respond to the needs of the region rather than to those of the nation (Holznagel, 1988).

The Educational Products Information Exchange (EPIE) Institute

The EPIE Institute is a non-profitmaking, consumer-supported product evaluation agency. Founded in 1967, it is respected for the quality and quantity of its evaluations of all types of teaching materials and equipment. It is supported primarily by school consumers and contracts with state and local education agencies. It has also received grants from private foundations such as the Carnegie and Ford Foundations.

In 1981 the EPIE Institute and the Microcomputer Resource Center (MRC) at Teachers College, Columbia University, collaborated in a first project that systematically analysed selected microcomputer software. For the project EPIE's instructional materials analysis instrument was adapted to systematise the analysis of courseware in terms of its instructional design, developer's rationale, learner objectives, content, methods and approach, and tests and means of evaluation. EPIE has continued since then to develop an approach to courseware evaluation that it believes to be responsive to the changing and evolving field of educational computing.

The process used by EPIE involves the evaluation of packages by teams of evaluators which include a subject matter expert, an instructional designer (or educational psychologist) who is knowledgeable about microcomputer software, a practising teacher and a team leader. When all four team members have evaluated the package individually, a final report based on the four opinions is compiled. If possible, the software is then tried out with students, and any learner-feedback is included in the final report.

EPIE uses a network of reviewers trained to analyse intrinsic instructional design and to observe the effects on learners. EPIE has also conducted a large number of training programs for states that are setting up their own reviewing process. In addition, over the years a number of states have contracted with EPIE for the evaluation of their curricula and material, including software.

During the period 1982-85, EPIE evaluated approximately 1 000 software packages of which it found 7 per cent highly recommended for school or home use, 36 per cent recommended with reservations, and 57 per cent either *not recommended but may meet some needs* or *do not consider*. Since then EPIE sees the proportion of high quality software growing to about 12 per cent. However, it does not foresee the critical mass of software required to make a major impact on education, except possibly in the mathematics area.

EPIE also publishes TESS, *The Educational Software Selector*, a catalogue of some 11 000 packages published in North America. TESS is also available electronically as a database on CompuServe. However, since it has not been attracting much usage, it will be removed from CompuServe and made available in tape and disk format to regional centres.

EPIE stresses the importance of fitting software to the curriculum, and not vice versa, and is conducting research into the development of a database that facilitates the organisation and access of information on educational materials that align most effectively with a school's curriculum and with each other. This database, the Integrated Instructional Information Resource (IIIR), according to Komoski (1987), is helping to demonstrate how significant improvements in curriculum planning and instructional practice can be achieved by providing educators with access to well researched, systematically organised information that enables them to search for the specific software, textbooks, other instructional materials and tests that align most effectively with particular aspects of the curriculum.

San Mateo Microcomputer Center, California

In California 17 regional Teacher Education and Computer Centers (TECC) were set up in 1983 by the Office of Educational Technology of California's Department of Education as part of one of the largest and most innovative educational technology programs in the world. Their primary purpose was to provide staff development for teachers in all areas of the curriculum but especially in mathematics, science and the use of computers. As part of the provision of teacher support, the Microcomputer Center in the San Mateo County Office of Education was designated the statewide software library and clearinghouse to support the 17 TECC Centers. It has four major responsibilities:

- The development of a cadre of software evaluation specialists throughout California who will train teachers in their regions as software evaluators;

- The publication of the annual *Educational Software Preview Guide* of highly recommended software selected by the Educational Software Evaluation Consortium;
- The provision of rotating collections of software for preview and evaluation at the TECC Centers throughout California;
- The collection, publication and dissemination of classroom-based evaluations and the dissemination of information about software.

Other activities of the Clearinghouse have included the publication of software reviews, the co-ordination of the development and distribution of public domain software under the logo of SOFTSWAP, and the investigation of the possible electronic dissemination of software evaluations and related information.

Another major, related project of the California State Department of Education Office of Educational Technology has been the Technology in the Curriculum (TIC) project. Funded by the state at a cost of $2.5 million in 1984, this project aimed at making as easy as possible the use of technology by the average teacher and the integration of computer software and video into the normal set of curriculum objectives. The major end product of the project has been a package of materials published in 1986, 1987 and 1988 and distributed to all schools in California, containing a resource guide for each of the six basic subject areas (history/social science, language arts/reading, mathematics, science, foreign languages and visual and performing arts). Each guide contains an introductory paper on the appropriate use of technology in teaching that particular subject; an annotated listing of computer software and instructional video programs relevant to the subject; correlational matrices that link appropriate software with defined curriculum objectives, and model lesson plans designed to instruct teachers in the process of integrating technology into the curriculum. Another outcome of the TIC project was to help pinpoint gaps in the curriculum where quality software was not available. Five updates were published in 1987 and 1988 in an effort to maintain the currency of this project.

Unfortunately, California's showcase Educational Technology Program suffered badly as a result of budget cuts which reduced funding for the program from $26 million to $12.7 million for 1988. Many existing projects have been canceled entirely, others have suffered severe cutbacks. Among the casualties of the cuts have been the 17 TECC Centers, all of which have been closed. However, the work of the software clearinghouse continues to be funded, so the software evaluation projects and the software preview centres which previously were part of the TECC Centers are still in operation. The full effects of the cutbacks on the Educational Technology Program as a whole have yet to be seen (Lathrop, 1988).

The Educational Software Evaluation Consortium

The Educational Software Evaluation Consortium is an annual meeting of national, regional and state software review agencies in the United States and Canada to share information and produce an annual preview guide to quality educational software materials. The Consortium meeting is organised by the San Mateo Microcomputer Center. Most of the 29 organisations represented in 1988 are associated either with state/provincial departments of education, regional agencies or specific school districts. The 1988 membership consisted of the following organisations:

Alberta Education
Arizona State University Microcomputer-based Research and Learning

British Columbia Ministry of Education
California Educational Computing Consortium
California Software Clearinghouse
Chime, Oklahoma State University
Colorado Department of Education
CUE - Computer-using Educators
EPIE Institute
Florida Center for Instructional Computing
Florida Department of Education
Indiana Clearinghouse for Educational Technology
International Council for Computers in Education
Lancaster-Lebanon Public Schools, Pennsylvania
The Learning Exchange, Kansas City, Missouri
Los Angeles Unified School District, California
Micro-Ideas, Illinois
MicroSIFT
Minnesota Department of Education
Montgomery County Public Schools, Maryland
Nevada Department of Education
New York City Board of Education
New York State Education Department
North Carolina State Department of Public Instruction
Oaklands Schools, Michigan
Putnam/Westchester Boces, New York
Wayne County Independent Schools District (ISD), Michigan
Wyoming Department of Education
York University Faculty of Education, Ontario

The Consortium's annual *Educational Software Preview Guide* is a list of those packages which have been favourably reviewed at participating sites. Prior to its annual conference the members send in information about the packages which they have reviewed, both positively and negatively, in the previous 12 months. These findings are collated in a database that includes information from prior years. Following discussion by working committees at the annual conference, those packages for which a strong favourable consensus exists are selected for inclusion in the Guide.

Each organisation assesses a minimum of 100 products each year. The cumulative effect of sharing information in this way results in the evaluation of a relatively large number of products. For example, *The 1986 Educational Software Preview Guide* contained 573 product listings and was based on 4 822 separate assessments by consortium members (Bitter and Wighton, 1987).

The Consortium stresses that the guide is produced as an aid to educators in locating programs they may want to preview and recommends that educators should preview all software to determine its suitability for their instructional programmes and students. The guide is not intended to be a comprehensive guide of available software. Software that has not been reviewed by at least three agencies, that has been unfavourably reviewed, or that falls outside specified categories is not included.

The Consortium, which has operated since 1983 and which acts as a forum for software reviewing agency representatives to get together and compare notes, etc., is an interesting model for other regional, or even international, gatherings of software reviewers.

Florida Center for Instructional Computing (FCIC)

The Florida Center for Instructional Computing (FCIC) is included as an example of a state organisation located at an institution of higher education. It is located in the College of Education at the University of South Florida in Tampa. A resource centre for teachers, it was designated the flagship centre for software evaluation by the Florida State Department of Education and funded to provide reviews to educators.

FCIC has developed and extensively tested a set of evaluation procedures to be used by trained evaluators. Evaluators are normally classroom teachers who, wherever possible, use the software they are evaluating with students in the classroom; they are paid for their time spent evaluating software. Over 200 new packages are evaluated each year. Previously completed evaluations are researched and updated to maintain accurate and current information.

After a program has been evaluated, the publisher is sent a copy of the unedited evaluation and given the right of reply to the evaluation. All publisher comments are carefully considered before the review is edited for publication.

Evaluations are published annually in a single edition, @MICRO, which is distributed free of charge to every public school in Florida (approximately 2 100) as well as to all district-level instructional computing administrators and to all state public colleges and universities. The 1 200 evaluations published to date can also be accessed free of charge in a database through the Florida Information Resource Network (FIRN). In addition a microcomputer version of the database for distribution to schools is currently being developed.

FCIC also maintains a preview library of approximately 2 000 software titles for all levels and subject areas from pre-school to college. The software has been donated by the publishers for the purposes of evaluation and preview by educators with the intention of purchasing. The Center delivers evaluation and preview workshops to teachers and educational groups throughout Florida.

Software Evaluation Exchange Development (SEED)

The Software Evaluation Exchange Development (SEED) is included as an example of a regional collaborative effort by a number of state education authorities to provide a service to their schools which they themselves are not able to provide.

SEED was set up in 1985 by the seven states participating in the Southeast Regional Council. They include Florida, Georgia, North and South Carolina, Alabama, Louisiana and West Virginia, none of which had a systematic method for evaluating software. A training workshop for trainers from each of the states was held at which it was agreed that there were advantages to be gained from collaboration. Training materials have been developed and a training program in software evaluation set up to train certified reviewers.

There has been no external funding except that of clerical assistance by the regional council. Each state pays for the training of its own personnel.

Meetings have been held with the software suppliers and developers to explain SEED activities and objectives. It is hoped that through such meetings a dialogue can be opened between state people and hardware and software suppliers to discuss the software needs of education, the best ways to review software and the means of tackling problems such as software piracy.

With regard to the distribution of information, the view held is that since the State Education Departments have a leadership function within their own states, the service provided must be perceived as support to this function and not as an activity being set up outside that framework.

SOFTWARE REVIEW: DIVERSITY AND COMMON FEATURES

SOFTWARE CLEARINGHOUSES

The Structure and Operation of Software Clearinghouses

A number of different models of clearinghouses can be observed. They often reflect the constitutional organisation of the country with regard to education and can be distinguished as follows:

National agency with central funding

In this model the central educational authority has established a central agency. Funding is provided directly by the central authority for the clearinghouse, which co-operates closely with the local or regional authorities who fund their own operations. The aim is to provide a national service. This is the model which has been used in Australia for the National Software Co-ordination Unit (NSCU) and by the Council for the Ministers of Education in Canada (CMEC).

State or province agency with local funding providing service to own schools

In this model the clearinghouse has been set up and funded by the state or provincial department or ministry of education to provide a service to the state or province schools. Any service which is provided to bodies outside the state or province is purely coincidental. Examples of such clearinghouses are: Alberta in Canada; Florida, Minnesota, New York State, North Carolina in the United States; Queensland in Australia.

A variation on this model is provided by San Mateo which, in addition to providing a service to California, is also the organiser of the Educational Software Evaluation Consortium.

Regional co-operative with minimal central funding and principal funding from constituents

In this model a number of education authorities agree to co-operate for mutual benefit. Each authority trains reviewers, reviews software according to agreed standards, and supplies information to the other authorities. Each authority bears the costs of its own operation, and the central agency provides only clerical support as a kind of letterbox. This is the model being used by the United States Southeastern states in the Software Evaluation Exchange Development (SEED) project.

Independent agency with central funding providing service to anybody at minimal cost

In this model an independent agency has been set up with special central funding. The agency works independently of the state organisations. This is the model for Microcomputer Software Information for Teachers (MicroSIFT), which has funding from the Northwest Regional Educational Laboratory, and for the National Educational Resources Information Service (NERIS), which has funding from the United Kingdom Department of Trade and Industry.

Independent self-supporting agency providing service on a user-pays basis

In this model an agency perhaps initially set up with central funding has evolved into a position of being commercially viable and self-supporting through the fees it charges for its services. The example of this model is the Educational Products Information Exchange (EPIE) Institute, of which the evaluation of software is only one of its activities.

University-based, with or without external funding

In this model an agency has been set up at a university which has received external funding to provide a service to schools. Examples of this model are to be found in Australia at Curtin University of Technology, in Canada at York University and in the United States at the University of South Florida.

Funding Difficulties

An important issue faced by many of the agencies is funding. It is clear that most if not all of those described have suffered or are suffering from lack of resources to provide an adequate service. Many other agencies that provided an excellent service while they lasted have disappeared through lack of continued funding. There is therefore an almost desperate need for greatly increased funding at national levels to provide for the continued adequate operation of the existing agencies and the development of such agencies in countries where they do not already exist.

Keeping up with the Flood of Software

Another issue is the need for co-operation among agencies to keep up with the ever increasing quantity of software appearing on the market, insofar as curriculum and cultural differences among countries permit. Komoski (1987) estimates that the number of packages published each year in the United States and aimed at the school market ranges from 1 200 to 1 500. Few agencies manage to review more than 300 per year. There is considerable duplication of effort, often with several agencies in the same country reviewing the same software. Although the *Educational Software Preview Guide* is a considerable help to all agencies in North America in avoiding evaluating what has already been evaluated by other agencies, a large number of software packages do not get reviewed at all, or only long after they have been published. Latest estimates are that in the United States no more than 40 per cent of software is reviewed. A similar situation obtains in other countries.

This situation finds favour with neither the teachers nor the software publishers – the teachers because they are looking for timely advice and guidance on the latest software which the publishers are telling them does such and such marvellous things, and the publishers because they know that many teachers will hold off buying until they know that the software has been favourably reviewed by their favourite reviewing agency.

How are the More Reputable Reviewing Agencies Identified?

Despite the subjective nature of reviews, a number of reviewing agencies can be identified whose reviews appear to be more reliable than those of some other agencies. What are the criteria for judging reviewing agencies? Criteria to be looked for are the experience and expertise of the reviewers, the existence of standardized procedures for the training of reviewers, the existence of well documented processes and assessment documents used by the reviewers in formulating their judgements, the use of more than one reviewer in the production of the review and the use of an editor or writer to check the accuracy and consistency of the information provided by the reviewers.

MECHANISMS FOR THE DISSEMINATION OF INFORMATION

Mechanisms being used in OECD countries to disseminate information about software include printed catalogues and lists, electronic databases and microfiche editions of databases. The use of CD-ROM is also being explored.

Printed Catalogues and Lists

Printed information is produced by some agencies in the form of printed catalogues, for example, the *Catalogue des Logiciels* in France and the Council for the Ministers of Education Canada *Database for Educational Software*. Many agencies also produce printed lists of recommended or approved software for the teachers of the state or province. Similar to these are the annual *Educational Software Preview Guide* of the Educational Software Evaluation Consortium and *Only the Best*.

Major difficulties with printed guides and catalogues are that they are expensive to produce, even if the information is already stored in a database, and, because of the rate at which software is being published, almost inevitably, they are out of date before they are even printed. If they are to be comprehensive they also tend to be rather bulky and are consequently often off-putting. The big advantage of such catalogues, on the other hand, is that teachers are familiar with handling printed materials. Until such time as the use of telecommunications becomes commonplace and more than just a dream for many OECD countries, such catalogues will remain the standard means of providing teachers with information.

Electronic Databases

A number of electronic databases have been developed including the following: RICE (Resources in Computer Education) by MicroSIFT, TESS (The Educational Software Selector) by EPIE, @MICRO by the Florida Center for Instructional Computing in the United States, the Council of the Ministers of Education Canada database and the York University database in Canada, NERIS (National Educational Resources Information Service) in the United Kingdom, and the NSCU (National Software Co-ordination Unit) and SCOR (Schools Computing On-line Resources) databases in Australia.

The Funding of Electronic Databases

Many of the databases that have been set up in OECD countries have suffered or are suffering from a lack of adequate funding for their continued maintenance and existence. A number of the databases appear to have been set up as part of projects lasting a finite period of time. When the project has ended, no provision has been made for the continued maintenance and updating of the database. Sometimes it would appear that the effort and resources required to maintain the databases have been underestimated.

The Use of Electronic Databases by Teachers

A number of databases appear not to be used by teachers and schools as much as might be expected. There are a number of reasons for this.

First, many schools have difficulty meeting the costs involved in accessing the database. These include the cost of modems, the communications costs and the charges for being on-line to the services. Communications costs often include the installation of an additional telephone line, telephone charges which might involve long-distance charges and, where necessary, charges for the use of national packet switching or similar services. Where these costs are government-subsidised, as in the case of United Kingdom's NERIS database, the service appears to be used more frequently by schools.

Second, unless the database is kept up to date with information about the latest software and current reviews, teachers will find the database of little value in solving their problems.

Third, even when the facility to access the database is available within the school, many teachers find the enquiry language used to access the database too difficult to learn and use on a casual basis. Since few teachers have received training in the use of on-line databases, they are unlikely to use databases which require spending a considerable amount of time learning the system or getting somebody else to search the database for them.

A number of databases are accessible by means of the STAIRS software. Whilst this software is an excellent tool for the information scientist or the trained librarian, it would appear to be far too difficult for use by the casual teacher user with minimal training – at this stage in the development of teacher expertise – and consequently not suitable for general use. Other software systems such as DOBIS/LIBIS would appear to be even less likely to be successful service providers.

Perhaps another reason for teachers not using many of the existing databases is that, having become familiar with microcomputers, they are now asked to use what appears to them to be a different medium. Rather than being able to use the machine with which they have become relatively confident, they now have to learn about things such as modems, baud settings, line speeds, stop bits, logging on and off, account numbers and passwords, etc. At this stage, from the psychological point of view, it is perhaps asking a little too much to expect the average teacher to be able to set up his/her own communication link. However, it is noteworthy that when all of this is done for him/her, the average teacher will use such databases enthusiastically (Winship, 1986).

There is also something of an inconsistency in asking teachers to access some distant mainframe-based database to get information about uses of microcomputers. It would appear more appropriate to have information delivered to teachers by means of the microcomputers they are actually using. Unfortunately there do not currently appear to be any adequate microcomputer-based systems which allow for the volume of data needed to be stored or provide an easy to use enquiry language. There is therefore an urgent need to develop adequate microcomputer-based systems to deliver information to teachers. The use of CD-ROM linked to a microcomputer appears to have the potential to satisfy this need. Resources therefore need to be made available to develop this potential, either at the international or at the national level.

Despite the problems of mainframe databases described above with respect to the delivery of information to teachers, they currently appear to be the most appropriate and efficient means of storing and updating information on software. As with the reviewing of software, there is duplication in the development of databases – if not at the national level, then certainly at the international level. It would appear that considerable savings in resources could be achieved and benefits gained if there were either an international database of information about software or at least the interchange of information among databases. An examination of the various databases shows that they all contain very much the same fields of information and in most cases would allow for easy exportation of data to other systems and importation from other systems. It is unfortunate that some national databases have been and are still being designed without this key principle of portability of data being built into them.

The Requirements of Electronic Databases

Perhaps the major reason for the ineffectiveness of many of the databases is that they have been designed without keeping in mind the end-users, the teachers, teacher-educators and parents. If a software information database is to be successful, it should be designed and implemented in such a way that it meets the following requirements:

Information needs of teachers

It has been found that teachers need the following types of information in such databases: descriptive information of the contents, objectives, and intended audience of the software; descriptive information of the hardware and software requirements; evaluative and review information about the software; information about guides pertaining to the place of the software in the curriculum; examples of good practice and descriptions of ways in which other teachers have used the software and found it effective (in this respect there is a need for more projects like the Michigan Disc Project, which incorporates teachers' notes as an integral part of the software review compiled by teachers, and the Harvard Educational Technologies Database, which began to compile a directory of information on the uses of microcomputers in educational settings in the United States); information which enables teachers to access the software to preview and purchase it.

Ease of enquiry language

The database has to be easy to access in terms of the enquiry language used and has to be designed in such a way that occasional inquirers can use it without special training. Teachers do not have a lot of time for or interest in learning a complicated language which they will use only on occasion. When they do use it, they do not normally have much time to spend working out what it is they must do. If they cannot access the database and find something useful to them in the odd ten minutes of spare time they have, then they will not use the database.

Ease of access

The database has to be easy to access in terms of the communication hardware and software available to schools. If schools have to purchase special equipment or software in order to access the database, they will be reluctant to do so. Although it is theoretically possible for most schools to have the capability of linking their own computers in one way or another to a computerised information system, in practice this is unrealistic given existing levels of resources, including the availability of computers, modems, appropriate telephone facilities and the money, time and personnel to operate the system on a regular basis. A flexible approach to user access is therefore required which includes on-line access to the host mainframe, microcomputer-based versions or extracts of the database, printed guides, microfiche and CD-ROM.

Import and export of data to database

Subsets of the database, or possibly even larger elements of the total database, need to be capable of being transferred electronically and easily to other mainframes, microcomputers or other media such as print, microfiche and CD-ROM. Similarly, these databases need to be designed in such a way that material from other similar databases or information providers can be easily and electronically incorporated into them without the need for re-keying the information.

Control mechanisms

A fundamental issue related to the use of databases is that of whether any control should be exercised on the contents of databases made available to teachers. How much information should be put before teachers? Should they be told about all the available software, even that of poor quality, and be allowed to choose for themselves? Or should they be told only about the best in terms of technical quality and educational practice or curriculum fit? In the latter case, who determines which is the "best"?

The OECD/CERI study *New Information Technologies* (1986) has identified two families of strategies which are being used by education authorities to control the quality of educational software. The same strategies are also used to control the quality of information. In the first, which it calls "preventive", the authority tries to ensure quality by issuing guidelines for teachers wishing to produce software or by controlling the authorship of software. So, for example in the United Kingdom, the MEP produced the *Educational Software: a Creator's Handbook*, and in Australia the Commonwealth Schools Commission produced *A Guide to the Design and Development of Educational Software*. The alternative "preventive" strategy is to control the authorship, either by having the software produced "in house" by especially hired personnel or by making software production an important part of the teacher training programmes. Examples of the first are to be found in the exclusive production and distribution of software by the computing branches of some of the Australian state education departments and of the second in the French advanced programme for the training of teachers.

The OECD study terms the second family of strategies "remedial". They do not attempt to influence the production of software but try to monitor and control the stream of software which actually penetrates into the schools. The means employed is for the authority to issue lists of approved software. Examples of this strategy are to be found in the status given to software by Alberta Education. Another strategy is for the authority to become the principal software distributor to schools by obtaining it from suppliers through bulk purchase deals or discount arrangements, and reselling or distributing the software to schools at greatly subsidised prices.

Many of the same preventive and remedial strategies are applied to control the quality of the information which is allowed to flow into schools by, for example, restricting the information in the published software catalogues or databases only to that which is approved or is from a "safe" source. Fortunately, this is by no means always the case, and in many authorities teachers are allowed access to a full range of information.

Chapter 4

THE NATURE OF SOFTWARE REVIEW AND EVALUATION

SOFTWARE REVIEW OR SOFTWARE EVALUATION?

The terms *software review* and *software evaluation* are often used to describe a form of critical appraisal of a piece of software. A major difficulty when discussing them in an international context is that they appear to have different meanings for different authors and in different countries. In some countries, for example, the United States and Australia, the terms are used synonymously as a judgement about the value, worth, appropriateness and usefulness of a piece of educational software and are used loosely and interchangeably for activities ranging from sales descriptions of software in magazines to in-depth critical appraisals conducted by academic researchers. In other countries, for example the United Kingdom, the term "software evaluation" is reserved, in the classical meaning of evaluation, for critical appraisals of software involving in-depth testing, and anything less than that is called a "software review". In other countries, for example France, the one term, "software evaluation", is used to describe any kind of critical appraisal. Thus, what one author calls software review another calls software evaluation; what appears impossible to one author is perfectly reasonable and feasible to another, and what is a purely subjective opinion to one author has a level of objectivity for another.

In this study, the terms are used as follows: Software review and evaluation can be thought of as a continuum with various shades of meaning and interpretation depending on the methodologies used and consequently with various levels of objectivity and usefulness. At one extreme of the continuum are factual descriptions of the software without any evaluative comments; at the other are evaluations which are the outcomes of studies by academic researchers adhering to rigorous norms of scientific enquiry. In between are reviews which reflect the personal viewpoints of the reviewers and reviews which are the consensus of a group of reviewers. There are reviews and evaluations which include data collected during the observation of students in the classroom and reviews which have been written without such observation. There are reviews written by classroom teachers and reviews written by "experts". There are reviews and evaluations which include the comments of students and those which do not.

In the context of this study three terms are used: *software description*, *software review* and *software evaluation*. The first, "software description", is used for an objective and informative description of a piece of software. The second, "software review", is used for a critical appraisal by one or more persons of the educational value of a software package as a teaching or learning tool. This often implies that it is a personal reaction or critique as with reviews of books, films and television programmes. The third term, "software evaluation", is used for a judgement about the value and usefulness of a piece of software involving an in-depth analysis and observation of the use of the software by means of quantitative and qualitative measurements and methodologies. Both software reviews and reports of software evaluations normally include a full software description. Both software reviews and software evaluations can be technical or educational.

Software descriptions are objective and factual statements about the software package, including information of two types: technical and pedagogical. The "technical description" includes bibliographic information such as author, publisher, distributor, length of software program, cost, the hardware and software required to run the package, including type of screen, peripherals such as mouse, light pen and joy-stick. The "pedagogical description" indicates the subject area and specific topics that the package deals with or is used in, for example, mathematics and multiplication; subject, type of software (tutorial, drill and practice, simulation, discovery, etc.), the target audience, the educational objectives, curriculum congruence, a description of the user support materials; the contents and structure of the package, including an abstract of the package, the instructional strategy used and a statement of the flow and sequence of the program.

Software reviews involve the description and appraisal of the software by one or more teachers and/or experts. The opinions of the reviewers may or may not be backed by descriptions of how the software was used by the reviewer or by observations of usage of the software in the classroom. The published review may be one written by the individual reviewers or it may be a consensus statement of the views of the reviewers put together by the agency. Reviewers often use a check-list or review sheet and follow a set procedure in reviewing the software.

Many of the reviews or "evaluations" produced by the agencies described in Chapter 3 can be classified as "software reviews", as defined above. In the past a measure of objectivity has been claimed for reviews conducted by trained reviewers, especially for those which are consensus statements. However, it is now generally accepted that since they are made in the context of the reviewer's value system, with his/her conception of what constitutes good or bad education, such reviews are by nature subjective and there can be as many different reviews as there are reviewers.

Software evaluation is distinguished from software review by the in-depth observation of the use of the software which normally takes place in evaluation. Evaluation techniques used might include pre- and post-testing or detailed observation of student use. Software evaluation can be either formative or summative. *Formative evaluation* is intended to provide evidence which can be used in the further development of the software, whilst *summative evaluation* sets out to make a judgement about the value of the software as an instructional tool in terms of its success or failure to achieve its objective.

Both software review and software evaluation can be either technical or educational, although they are rarely considered separately. *Technical review or evaluation* is a judgement about the technical aspects of the software, such as its robustness and reliability under normal conditions, the design of its displays, its ease of use, procedural instructions and prompts, user control and, if applicable, its quality of colour, sound, graphics and animation. Since the criteria on which judgements are based usually meet with general acceptance, it is relatively easy to have agreement on the technical aspects of a software package and to have the judgements accepted as being objective. Technical reviews or evaluations are often carried out using a check-list of features to be looked for. The program either passes or fails each test.

> "The skills needed by the technical evaluator are those of knowing what to look for, thoroughness, persistence and the doggedness of a bloodhound in trying out every aspect of the program to check for quality failure" (Anderson, 1985).

Educational review or *evaluation*, on the other hand, is a judgement about the educational value of a piece of software as a teaching or learning tool. For example, the content is accurate and educationally valuable, the level of difficulty is appropriate to the specified audience, or the software achieves its stated objectives.

These concepts and related issues are expanded upon in the following sections of this chapter which look at the value and validity of software reviews, the review process, the criteria used in reviewing, the reviewers, software evaluation and the need for evaluative studies and research.

THE VALUE AND VALIDITY OF SOFTWARE REVIEWS

Judgements on the educational value of a piece of software are often widely divergent. For example, one teacher might argue that a package provides many repetitions at the same level of difficulty and that consequently students are bored by it. Another teacher, however, might point out that students find the concepts dealt with in the package difficult to grasp and that they need a considerable amount of practice to ensure understanding. Judgements must therefore be firmly supported by a description of the educational context in which the package is used. If the reviewer's context and mode of use are sufficiently similar to those of the reader of the review, the latter can judge whether the reviewer's conclusions are relevant or not.

Reviews should also make clear the educational viewpoint of the reviewer. For example, the comment "I do not like the shapes used on the screen display" is purely subjective and of no value in guiding others to making a decision regarding the software. On the other hand, the comment "I do not like the shapes used on the screen because they are abstract and young children are more able to work with the familiar and meaningful when new concepts are being introduced" exposes the educational viewpoint of the reviewer to the reader and allows the reader to form a judgement based on his/her own educational viewpoint.

It is interesting to note the existence of at least two projects reported on which have attempted to collect information about the reviewer and to relate this to the review. In the first, the Centre for the Study of Systems and Advanced Technologies (CESTA) experimented with the use of two forms. The first form, concerning the performance of the software in classroom use, is completed by the reviewer. The second form focuses on the teacher-reviewer, for example, his educational attitudes and practices, his conceptions of the teacher's role and his expectations from the software (Barchechath, 1987).

The second project, known as DÉVISAGE, which has been developed at the Centre for Educational Technology at the University of Liège, uses the spreadsheet software *Symphony* to weight the importance of criteria by which software is evaluated. Criteria weighted include interactivity, style, adaptability, validity of strategies used and cost-effectiveness (Leclercq, 1988).

A fundamental issue related to software reviews is their validity. Since software reviews are by their nature subjective assessments based on the value system and educational viewpoint of the reviewer, typical questions teachers might ask are: How well do the reviews indicate the effectiveness of the software in classroom use? To what extent can teachers rely on them in selecting software?

Jolicoeur and Berger (1986) examined the adequacy of published evaluations or reviews of software as measures of effectiveness. Many of these reviews are used by educators with the expectation that the ratings are valid indicators of how well the software will work in the classroom. For their study, Jolicoeur and Berger chose, from the many sources of reviews, EPIE and MicroSIFT as being among the best collections of reviews.

Their conclusions were, first, that although on the surface the procedures used by EPIE and MicroSIFT appear intuitively sound, both methods suffer badly by psychometric standards, in so far as the summary reviews of the programs are based primarily on the reviewers' subjective opinions rather than on operationally defined variables. In both cases the review form asks the reviewer to give ratings, in the case of EPIE in the range of 1 to 10 on the quality of instructional design, and in the case of MicroSIFT of 1 to 5 for content, instructional and technical characteristics. Raters are likely to have a variety of opinions regarding what constitutes educational qualities. Furthermore, since educators reading the reviews have their own subjective opinions regarding what constitutes high instructional and technical quality, their interpretations may be very different from what the rater intended.

Second, in order to assess the validity of these subjective judgements, Jolicoeur and Berger next compared the reviews of 82 packages from EPIE and MicroSIFT. They found that the correlation between the reviews was far below acceptable levels of reliability both in the overall recommendations and in the more narrowly defined characteristic of instructional design.

They concluded that the only way to establish the validity of a reviewing system, to judge its ability to predict that a specific piece of software will attain its educational objectives, is to demonstrate by means of controlled outcome studies that highly rated programs do in fact teach their objectives better and/or faster than lower rated programs. They further concluded that we do not know which specific factors contribute significantly toward making educational software more or less effective and that without a much greater number of outcome studies, it is not possible to develop a valid method.

> "There is a pressing need for objective information on the effectiveness of educational software programs. Until we know how specific characteristics of software influence instructional effectiveness, educators can only guess at which programs will work best in their classrooms, software developers can only guess at which instructional and programming features make their software more effective as teaching tools, and reviewers of software will be limited to subjective judgments with questionable validity" (Jolicoeur and Berger, 1986).

Despite their drawbacks and shortcomings, software reviews can be very useful guides to teachers in selecting educational software. They are helpful indicators to teachers of software that might be useful to them or that should be rejected. As is true for any critique, however, whether of a work of art, a book or a software package, the experience and expertise of the reviewer have to be taken into account when judging the credibility of the critique. No matter how reliable the reviewer, in the final analysis it is the teachers who must decide whether they can use that particular software package and how they will use it. Often what is useless to one teacher can be extremely useful to another in different circumstances with different types of students.

As a corrective to the necessarily subjective and personal viewpoint of educational reviews and so that readers can judge their validity, publishers of reviews should include information such as the following:

1. Who were the reviewers? What experience have they had with the subject matter, intended student population, and instructional techniques of the courseware?
2. How many students used the courseware? Under what conditions? What were their background and abilities?
3. How did the reviewers collect the information used for their conclusions and judgements?
4. How were quality ratings determined? What evidence shows that the ratings of these reviewers validly predict courseware effectiveness? (Avner, 1985)

THE REVIEW PROCESS

Agencies actively involved in software review have very similar processes, instruments and assessment documents. This seeming duplication of effort results from the fact that these documents, instruments and guides have been developed over the years as part of the learning and training process of the teachers and other personnel involved in developing and setting up the agencies. The actual drawing up of the documents appears to have been as important as the end result in the development of the agencies. There are consequently almost as many review and evaluation instruments and guides to reviewing software as there are reviewing and evaluating agencies.

The processes which are being used by many agencies have the following in common:

- Description and cataloguing;
- Sifting and elimination of software having unacceptable fundamental weaknesses;
- Peer review;
- In-depth evaluation.

Description and cataloguing

This stage is normally completed by the clearinghouse before software is assigned to reviewers. It involves the description and cataloguing of the software packages and includes packages that have been rejected at the screening stage together with the reasons for their rejection. This notification of the rejection can be as valuable as the seal of approval on a piece of software in saving the potential buyer's time.

Sifting or screening

All software goes through an initial screening by clearinghouse staff. The purpose of this stage is to screen out as yet unreviewed software that has an excessive number of fundamental weaknesses. The reviewer is asked to give an overall "gut reaction" to a piece of software. Is it worth reviewing further or has it weaknesses that make this not worthwhile? Major strengths and weaknesses are noted, but the existence of weaknesses does not necessarily exclude the package from further review. In some cases the considerations may not be appropriate or relevant to the type of software being reviewed. In other cases the strengths of the package may outweigh the weaknesses. Some reviewers find a check-list an aid to forming an opinion. Successful passing of this screen is not a recommendation in itself. A favourable report at this stage is merely an indication that the software is considered worth reviewing further.

Peer review

Software is then reviewed by teams of trained (and in some organisations "certified" or "accredited") reviewers including practising teachers in each of the particular subject areas. A minimum of three appears to be the accepted size of the team.

First, software is reviewed by members of the team outside the classroom; then, where possible, it is trialled in the classroom with students. A suggested procedure for reviewing, using the appropriate review instrument, is:

- Ensure that all components of the product are included in the package;
- Review all instructional materials accompanying the product (guides, instructions, handbooks);
- Check the hardware requirements;
- Run the program to get a feel for it. Explore the objectives, content, instructions. Does it run?
- Be a *good* student and work through the program in a positive manner and try to react as that type of student would;
- Be a *poor* student and go through the program again. Press wrong keys; give wrong answers repeatedly; misunderstand the instructions; try to *crash* the program;
- Complete the review form.

In addition to a description and a technical appraisal of the software, software reviews usually contain evaluative comments about the software package under the headings of content and instructional characteristics. In examining the content characteristics, the reviewer checks and then makes a judgement on, for example, whether the content is accurate, has educational value and is free of race, ethnic, sex or other stereotypes. Consideration of the instructional or pedagogical characteristics involves assessing, for example, the level of interactivity of the package, the questioning techniques used, the feedback provided to the user and the effectiveness of the software as a teaching or learning tool.

Check-lists are used by many agencies both for performing assessments and for presenting assessments. However, they do not find favour with all commentators. Avner (1985), for example, says:

> "Examination of the reviews of misrated courseware shows that most of the inaccurate ratings are the result of the uncritical use of prescriptive check-lists. For example, courseware might be given added points for use of colour, animation, sound, or a given instructional approach – regardless of whether the use was appropriate. Reviewers who used functional rather than prescriptive check-lists tended to look beyond superficial features and had fewer miscalls. Their errors tended to be misjudgements of the effectiveness of specific instructional approaches or of the interests and abilities of the student population".

A summary review or synthesis of the reviews is then drawn up by one of the team, or jointly by the team working together, or by a member of the clearinghouse staff. The review often culminates in scaled recommendations such as:

- Highly recommended;
- Recommended with little or no change but suggestions for effective use are noted;
- Recommended only if certain changes are made as noted;
- Not recommended.

Many different formats have been used to present printed reviews. Some agencies such as Alberta Education prefer a full review combining both a description of the software with associated evaluation under headings such as Pedagogical Content, Instructional Format and Technical Characteristics. Others, such as Queensland's SUGAR and New South Wales Computer Education Unit, use a checklist with room for a few comments. Others such as MicroSIFT use a combination of both descriptions and checklists.

A practice common with some reviewing agencies is to give star ratings to software. Anderson (1985) has this to say about such star ratings:

> "Several review groups have tried to use their own standard of star ratings. The practice is most questionable. On occasions technical and educational assessments have been combined into the same star system. Several important aspects of use are disregarded. For example, the context in which the software is used, and the capabilities of those using it are not considered. Further, individuals are discouraged from making their own assessment based on experimental evidence. Star ratings are certainly open to misunderstanding and worse, have been abused, sometimes by publishers themselves".

Anderson (1985) criticises also the consensus approach in reviewing software since in his view such an approach eliminates the range of viewpoints of the team members. See also the view of Olds with regard to the MicroSIFT process described in Chapter 3.

CRITERIA USED IN REVIEWING SOFTWARE

There is considerable overlap in the definition of the criteria used by reviewing agencies such as those described in Chapter 3 to judge the quality of software.

One of the problems with drawing up lists of such criteria is that, in many cases, all criteria are given equal weighting or importance in reviewing the software. For example, the presence or absence of colour or graphics might have no significance at all in the case of some types of software such as spreadsheets or database management systems. Making the use of these features an essential criterion of assessment can distort the end review of the product.

Another problem is that the same criteria are used to assess different types of educational software. The criteria for judging a tutorial would appear to be different from those used for judging a spreadsheet or a word processing package. Careful attention needs, therefore, to be paid to considering whether particular criteria are appropriate in particular cases.

A further issue that Komoski (1987) has pointed out is that many involved in evaluation have approached it as though software were some totally new type of learning material to be evaluated only by its own set of criteria without considering how it reflects the best of current thinking within its subject area.

> "Although educational software is a unique medium it is not so unique that it can be excused from being judged by the canons of good teaching and established principles of learning - including the degree to which it validly and accurately reflects the best of current thinking within a discipline. ... it is important for evaluators of educational software to move beyond the assumption that all software can be evaluated by means of a set of generic criteria. The time has come for the development of specific criteria for judging the quality of software in different disciplines. Many have been aware of the need to do this but have continued to use generic criteria because of the exigencies of time and the continuing deluge of software to be evaluated".

A number of agencies have begun to develop instruments which are subject- or software-type-specific. For example, Alberta Education has produced an instrument used in the review of accounting software and word processing software, the National Council of Teachers of Mathematics (NCTM) of the United States has developed an instrument specifically for the review of mathematics software and the National Science Teachers Association (NSTA) of the United States has done the same for science software.

Yet another issue is that, although the same standards for the technical excellence of educational software appear to apply across cultural, international and curriculum boundaries, software still needs to be assessed for how well it fits the curriculum in which it is going to be used. Thus a piece of educational software might be excellent in itself as far as its technical or even its educational aspects are concerned, but it still needs to be considered for its appropriateness or congruence in the curriculum. This need for curriculum fit is particularly important when software is being assessed for use in countries other than the country of origin of the software. It is even the case in North America, where otherwise excellent United States software is rejected in Canada because of lack of curriculum fit.

What Criteria are used in Reviewing Software?

Bitter and Wighton (1987) report an interesting study using the Delphi technique on the most important criteria used by the 28 members of the Educational Software Evaluation Consortium. Since the members come from different areas and represent organisations with varying purposes, it is not surprising that the evaluation methods and the criteria on which the assessments are based also vary. Out of curiosity as to the extent of the differences and to help evaluators review their own evaluation processes, the members tried to identify the most important characteristics of quality educational software. The first part of the study was a request to the members of the Consortium to identify the 20 most important characteristics used to evaluate software. Some 16 of the 28 members replied, giving a total of 320 criteria. The most common criteria from these were identified and 22 of them selected. Each Consortium member was then asked to rank order the 22 criteria. 86 per cent of the membership rank complied, and an average rank score was then computed. The rank was as follows:

Rank	Characteristic
1.	*Correctness of content presentation:* the program is free from content, informational, computational, grammatical and syntactical errors;
2.	*Content presentation:* the pedagogical content is presented in a clear, concise, logical and manageable fashion and in sufficient depth of instruction and/or practice so that learning will take place;

3. *Use of technology*: this is an appropriate use of computer technology, such that the program takes full advantage of the computer's capabilities and provides students with a learning experience that cannot be presented better in another medium;
4. *Integration into classroom use*: the program can be effectively and easily integrated into classroom use; the software lends itself to use within a classroom time frame; effective and appropriate teacher support materials are available; the program can easily be used by the teacher;
5. *Ease of use*: the program is user-friendly;
6. *Curriculum congruence*: the content directly supports the curriculum;
7. *Interaction*: interaction is effectively achieved for the target audience; there is a sufficient amount and a sufficiently high quality of it to promote learning;
8. *Content sequence/level*: There are multiple levels of difficulty with appropriate incremental steps among the levels; the development sequence and the difficulty of the levels are appropriate to the target audience;
9. *Reliability*: the program is free from programming and technical errors;
10. *User control of program*: the user (student or teacher) can control the rate, amount and sequence of presentation;
11. *Feedback (general)*: the program correctly assesses student input and provides appropriate and effective feedback messages;
12. *Objectives*: the objectives are clearly stated and met;
13. *Motivation*: the program is motivational;
14. *Branching*: there are branches to provide individualised instruction according to each student's needs;
15. *Negative feedback/help*: corrective feedback messages or help screens are provided as needed;
16. *Content modification*: the content can be modified by the teacher;
17. *Content bias*: the content is free from bias (race, sex, cultural, ethnic, stereotyping, violence);
18. *Teacher documentation*: the documentation is comprehensive, easy to understand and well organised;
19. *User support materials*: there are user support materials which are appropriate and effective;
20. *Colour, sound, graphics, qnimation*: when present, these features are used effectively to enhance the program;
21. *Screen displays*: screen displays are effectively and appropriately formatted;
22. *Management system*: there is a management system which provides an effective means for record keeping and/or assignment control.

Bitter and Wighton conclude that the results indicate a strong emphasis on content and pedagogy versus computer-related characteristics. The emphasis in software evaluation has shifted, according to them, from consideration of the purely technical aspects such as screen displays, colour, sound, graphics and animation, which are now assumed characteristics, to the appropriate use of the software in the curriculum.

They conclude:

1. Software evaluation instruments need to emphasize content-related criteria.

   Many of the older check-list instruments seemed to emphasize technical questions. Hence, it was common to find reports that discussed program reliability, use of colour and sound, etc., but gave little attention to pedagogical content;

2. Teachers should focus software review on the *educational* half of the term *educational technology*.

   Five of the top eight criteria relate to the pedagogical content and measure the educational value of the product;

3. More research needs to be done to determine the most effective computer feedback which can be provided to the learner.

   It is important for developers and reviewers to consider interaction, feedback, user control, branching and corrective feedback;

4. Teachers, reviewers and developers of software should first consider sound pedagogical principles.

Whilst a useful and interesting study, a few comments are perhaps in order. First, clearly the abbreviated list of characteristics should not be used as a check-list of criteria without further explanation and expansion of the characteristics. Second, one wonders whether the methodology used was not a little too simplistic and how much the rankings were influenced by the type of software predominantly being evaluated by the agencies. In other words, would they have ranked the criteria in the same way for different types of software, for example for drill and practice, simulations, databases?

One wonders, too, how much the ranking reflects the North American tradition and tendencies in the field and whether it has relevance to other countries. Outside of North America, North American agencies are often criticised as being irrelevant to other nationalities because of the emphasis on drill and practice and the consequent perceived orientation of the reviewing instruments and methodologies towards that type of software. Despite the comments of Komoski and Olds quoted above, it often seems as though most North American agencies review or "evaluate" all software using criteria for drill and practice or tutorial software.

There is a need for much further research to identify the criteria for assessing the different types of educational software for different subject areas and for evaluating the contribution of specific characteristics to the effectiveness of educational software. A Delphi technique investigation into the criteria used by reviewing agencies in OECD countries might be quite an interesting study, for example, especially if it were done in three dimensions, with the first being the criteria, the second the mode or type of software being used and the third the subject area. Although such a study might only be an indicator of what the agencies *think* the characteristics of good software are, it could serve as the framework for identifying topics for further research and evaluative studies in the field.

Are there Indicators of Excellence in Educational Software?

In 1985, the California State Department of Education published *Guidelines for Educational Software in California Schools*. Under the headings of educational content, technical features and support materials, the document identified criteria for software which it considered essential, desirable and indicative of excellence. Educational content relates to the educational material to be presented and the teaching and learning strategies used. Technical features deal with the program's operation. Support materials are the supplementary materials that teachers and students must have to operate the program. The essential and desirable criteria can be identified among the criteria listed by Bitter and Wighton. The indicators of excellence are important as being possible future directions for software development, incorporating many of the results of research in the cognitive sciences referred to in Chapter 2, improvements in hardware technology, and advances in instructional design. Some indicators are already being seen in available software. They are as follows:

Educational content

1. The software uses innovative approaches and encourages the learner to be creative;
2. The learner is encouraged to use higher-order thinking skills, such as application, analysis, synthesis and evaluation, where appropriate;
3. Alternative methods of presenting the content are used and are based on the learner's responses;
4. The software allows for open-ended, natural language responses;
5. The software presents material not easily provided by other methods, or engages the learner in experiences not readily duplicated in the real world, or presents material in a way which makes it accessible at an earlier grade than in the traditional curriculum.

Technical features

6. The program provides for various learning modalities, e.g. auditory and visual, where appropriate;
7. The software uses other technologies such as speech synthesis, videotapes, videodisk or audiocassette to enhance the learning experience, where appropriate;
8. The software uses alternative input devices such as voice, light-pen, mouse and graphics tablet, where appropriate;
9. The learner can exit the program at any point and return to it directly from the beginning of the program, maintaining previous work intact in the process;
10. The learner can go back through the program on demand to review responses and content;
11. A comprehensive learner management component is included, where appropriate;
12. The program includes the capability of printing appropriate instructional segments, performance records, learner-created materials, etc.

Support materials

13. Accompanying teacher and classroom materials describe the specific learning theories on which the instructional design is based;
14. Accompanying materials include masters for transparencies and learner's materials, well designed pre- and post-tests where appropriate, additional references and resource materials and suggestions for a broad range of classroom activities;
15. Teacher's materials describe the correlation of the material to standard textbook series, curriculum frameworks and standards where appropriate;
16. Accompanying materials describe learners' outcomes obtained from field testing and trialling in a variety of settings;
17. Materials identify the previous work and background qualifications of the author(s).

Whilst some of these indicators are lacking in the majority of software available, it is important that teachers and schools be aware of them, begin to look for them and expect them in the software they are asked to purchase. Similarly, it is important that software developers be aware of them and begin incorporating them in their software.

By what Criteria do Students judge Software?

Based on a study of students' use of pure arcade games and game-based learning software, Malone (1980a) found that the factors motivating students were, in rank order: having a goal; the computer keeping a score; the audio effects of the software; the randomness involved in the games; the speed of answers; the visual effects; the sense of competition; the variable level of difficulty; co-operation and fantasy.

Since this seminal work little research has been conducted into the motivational effects of computers on students. One reason for this is the highly idiosyncratic nature of motivation which makes it extremely difficult to identify the factors or agents which are motivating at all, let alone equally motivating to all learners. Another is that concentrating on the computer as the motivating agent tends to present the learner as the passive object, being motivated, rather that the active participant in learning, seeking information and creating knowledge. A further reason is that there has been a tendency in evaluating software to focus on expert (adult) opinion and to regard learner motivation only as a desirable outcome and not as a reflection of the exercise of evaluative criteria by the learners themselves.

Smith and Keep (1986), however, have conducted some extremely interesting research into the criteria which children use to evaluate educational software. This work was part of a project carried out by the Centre for Evaluation of Information Technology in Education in the United Kingdom during which they interviewed 132 primary and secondary students about their views on the quality of educational software. Attention was focused on those aspects of software which made it interesting or fun to use and, by extension, to those features which made it uninteresting.

They found that the children in the study had well-established criteria against which they evaluated educational software. In most cases, their immediate perception of the computer was as a device for playing games at home. Computers and computer software were perceived as consumer goods and were evaluated against the production and presentation standards of the consumer market. There was little enthusiasm for home learning software. As one 12-year-old girl remarked: " ... I find I get enough education at school, without taking it home...".

The children's requirements were summarised by Smith and Keep (1986) as follows:

1. The program must involve several sensory modalities, using audio and visual effects;
2. Input requirements must be simple;
3. There must be an adequate but not excessive level of difficulty in the early stages;
4. There must be graded levels of progressively increasing difficulty;
5. There should be "surprises" and things to be discovered;
6. There should be no confusion of goals and objectives.

More research is needed to explore further the aspects of educational software which are attractive to students and apply them in software development. Above all, perhaps, in the words of the child quoted by Blishen (1969): *The pupil should be given a chance to speak and the teacher should be given a chance to listen.*

THE REVIEWERS

Who should the Reviewers be?

Since reviews are intended to help teachers in their selection of software, the most useful reviews are those written by other teachers. Only the teacher with classroom experience is in a position to know whether or not a piece of software will work with his/her students. Intimate knowledge of the subject matter is not sufficient. Reviewers must be able to predict whether the software will work in the classroom. An ideal situation would be to bring together all the reviews written by teachers using the software in a number of different classroom contexts so that the potential user could get a feel for the use of the software in a variety of classroom contexts and determine whether or not the item would be useful for his or her own needs.

An important issue concerning the review of software by teachers is that they – especially the more professional teachers whom one would expect to use – are extremely busy people with very little time for additional activities. This creates an apparently inextricable situation where the very people who are needed to do the job which will help other teachers, do not have the time to do it.

A related issue is that of the payment of reviewers. In many instances reviewing can be construed as part of a teacher's work and duties. However, in other instances, especially when reviews are to be published, there would appear to be a case for making an appropriate payment for the work done. This might be in the form of actual money or in time release from other duties. The alternative is to depend on the goodwill and enthusiasm of teachers to do the work. The experience of North America, however, is that the day of the unpaid enthusiast is over.

In emphasizing the role of the teacher in reviewing software, it must not be forgotten that the end-user of educational software is not the teacher but the student. Comprehensive reviews should therefore include trialling with students.

What Training do Reviewers need?

Because reviewing software requires skills, and because of the need for uniform standards, reviewers must go through a training process. Alberta, EPIE and MicroSIFT and most of the other reviewing agencies have stringent training programmes for reviewers and insist that this is the only way to establish credibility and standing. All three involve three or more reviewers in the compilation of the final published review.

Most agencies have set up programmes to train teachers as reviewers. For example, in setting up a small reviewing agency in Western Australia, an initial group of 20 secondary teachers underwent a training programme in software review. This group's previous experience in the use of software in the classroom was varied. Most were teachers of mathematics, science or computing and their experience in using software in the classroom ranged from considerable to negligible. Subsequently, another group drawn from other subjects at the primary and secondary levels received training and was used to review software.

The programme devised consisted of four two-hour sessions spread over three weeks. The sessions consisted partly of lectures on aspects of software review, partly of demonstrations of a number of packages (both good and bad in quality) in order to show a wide range of types of software, to highlight the particular characteristics to be looked for in good software and not to be tolerated in poor software. The group participated in drawing up appropriate reviewing instruments.

Between sessions members of the group took available software away with them in order to explore as much of it as possible. This was considered an important aspect of the programme. Each member of the group also individually reviewed three packages. Group discussions were then held and the reviews made by the individuals compared.

Once the training was complete, a number of ways of using the group as a reviewing agency were tried. One was to let the reviewers take software back to their schools with them and return it when they had completed their reviews. Most reviewers found in these circumstances that the work got pushed to the bottom of their pile of things to do. Another tack taken was to bring the reviewers together occasionally as a group. This was successful with some but it proved difficult to arrange suitable times for the group as a whole. A further tack was to use holiday periods to get them together.

A further issue is that of achieving consistency of reviews and reviewers, of the need to establish some method of rating the reviewers. How does one guarantee that the reviews by a particular agency are of equal worth? Some of the reviewing bodies such as MicroSIFT and Alberta subject their reviewers to a test at the end of their training programme so that they can be rated one against the other. Reviewers that pass the test are "certified" or "accredited".

SOFTWARE EVALUATION

Formative Evaluation

Formative evaluation is intended to provide evidence which contributes to the forming and reforming of a development. It lies at the heart of the cyclical model of evaluation. It assumes that a process of evaluation can identify where changes and adaptations should be made in a project or development during its lifetime. In terms of a curriculum development project such as the development of a piece of educational software, internal formative evaluation is an indispensable element in the development of an innovation and forms part of the cycle of:

Design -> Development -> Trial -> Redesign -> Redevelopment -> Retrial.

Such a cycle involves the identification of issues of interest, the collection of information about them, the sorting, analysis and judging of the information and then the making, monitoring and judging of changes to the development. It precedes final implementation and dissemination (Anderson, 1985).

Most software developments go through a process of formative evaluation even if the evaluator is only the author him/herself. There are a number of examples in the literature of formative evaluations of software produced in an educational environment. For example, Bork (1981) describes the process used at the Educational Technology Center at the University of California at Irvine; the *Guide to Evaluating Methods – A Manual for Microtechnology Innovation* (1982) describes the methodology advocated by the Microelectronics in Education Programme (MEP) in the United Kingdom.

Unfortunately many commercial publishers of software, at least those in North America, appear to place a low value on field testing of a product before actual publication. Truett and Ho (1986) surveyed 396 companies marketing software; 125 companies replied. Of the respondents 18 per cent did no field testing, while 52 per cent claimed to field test all of their software; 59.2 per cent of those field testing used six or fewer teachers for the tests; over 5 per cent used only local schools and 5) per cent used 50 or fewer students; only 12 per cent used student pre- and post-test scores, although 21.6 per cent did use student evaluations of the software.

Truett and Ho point out an interesting contradiction. While only 12 per cent included field test results in their documentation, 55 per cent claimed field testing enhanced their marketability. A third were uncertain of the value of field testing. In addition to teachers and students, expert reviewers were also used in evaluation (54 per cent used in-house experts and 46 per cent outside experts) but one-third of respondents let the author/programmer do the evaluation!

Truett and Ho (1986) conclude that since many companies do no field testing, or test only a small percentage of their software, or do not include their field test results in the documentation, the teacher can generally have no idea whether or not the software has been field tested and with what results. Since in most cases field testing involves fewer than six teachers, is done in local schools and involves 50 or fewer children, "Such field testing can in no way replace evaluation and preview by ... local teachers, who may be just as knowledgeable and whose evaluations are more relevant for their particular groups of children".

Komoski (1987) considers that two aspects of formative evaluation are too often neglected. First, the software developer has the responsibility to conduct a careful assessment of whether the software being developed reflects the best current thinking in the curriculum area it addresses. Since this is rarely done, much software ends up viewing the curriculum through the rear-view mirror. Second, fewer than 10 per cent of programs examined by EPIE are accompanied with evidence that formative evaluation has taken place. Such evaluative information should be collected for as long as the product remains on the market. This would make it possible to modify the product, since its effects and side effects are not initially apparent and since learner reaction to products sometimes changes radically over time.

Summative Evaluation

Summative evaluation, on the other hand, sets out to make a final judgement about the value of educational practices, materials, etc., usually in terms of its success, or failure, to achieve a certain objective of some kind. Summative evaluation normally involves extensive testing and use of the practice or package. Activities might include pre- and post-testing, or detailed observation of student use of the package. In the case of a piece of software, summative evaluation involves judging whether or not it has achieved the objectives claimed for it by the publisher, for example, increased problem-solving skills or knowledge of a topic. Few agencies are conducting such evaluations on a regular basis.

Educational Evaluation

There have been very few large-scale evaluation studies of computer-assisted learning and those that have been conducted have been concerned with larger and older mainframe systems rather than with the microcomputer systems used in classrooms today. In the 1970s in the United States, studies were made of the PLATO and TICCIT systems using experimental research designs. Other studies showed that computer-assisted instruction is an effective medium for improving academic skills in significantly less time than conventional methods (Kulik, Kulik and Cohen, 1980). In the United Kingdom, the Understanding Computer-Assisted Learning (UNCAL) evaluation of the National Development Programme in Computer-Assisted Learning (NDPCAL) concentrated on observational methods to create descriptive case studies of applications. From these case studies the evaluators invented a set of paradigms and typologies within which they could set different types of computer-based learning and clarify their potential educational value. They were particularly careful to stress the word *potential* in order to make the point that the realisation of the potential depended critically on the capability of the teacher (Anderson, 1985).

A number of qualitative instruments and methodologies of evaluation have been developed. They include user needs analysis, questionnaires, diary and record keeping, psychological instruments, structured observation and interview techniques. There are also the quantitative analysis of system statistics and user performance tests.

One difficulty involved in using such methodologies is the impossibility of comparing learning events of the traditional kind with those in which a software package is being used since no program presents the material as it would have been presented traditionally and its very use adds an extra dimension to the learning experience. A second is the difficulty, when comparing two different student groups, one using the package, the other not, of finding groups which are identical and altering just one variable so that any changes are attributable to the package and its use and not any other differences between the groups.

Because of these and the many other difficulties inherent in software evaluation, several different observation and measurement techniques are used to examine the teaching/learning activity from different angles. This approach, known as *triangulation,* looks for a convergence of similar or common results being obtained from a very wide range of different measurement techniques.

Some formal evaluations have been conducted. Bruce (1987), for example, quotes the evaluation he carried out with Rubin (1984) on the writing package *Quill*, and that by Levin, Boruta and Vasconcellos (1982) on *Writer's Assistant*, both of which gave favourable results.

Other encouraging studies have been those of the ALE (*Apprentissage de la Langue Ecrite*) Project at the Centre Mondial Informatique et Ressources Humaines (Cohen, 1987) and of Blemings (1987a) in *Microcomputers in Queensland Preschools*. Both of these studies dealing with pre-school children have produced evidence that there is software currently available which produces positive outcomes at that level.

One has to accept and expect, however, that not all evaluative studies give such positive results. Okey and Oliver (1986), for example, evaluated two highly regarded packages, *Raft Away River* and *Dirigible*, with results that were not so favourable.

In *Raft Away River* the students have to work together in a survival exercise, fishing and collecting food and wood for the fire. Using various methodologies Okey and Oliver evaluated learning outcomes from use of *Raft Away River* but were unable to measure any differences between the control and experimental groups. The students observed were good at the game but the researchers were unable to determine any transfer of the skills learned to other learning situations.

In *Dirigible* the students become the crew of a dirigible which they must fly over swamps, seas, buildings, hills and tall trees to land at their target. Okey and Oliver found that, in the case of *Dirigible*, the class interaction showed that the class worked well together on the task, that it interacted and endeavoured to analyse problems. However, they were unable to detect any discernible differences in the areas of mapping skills, estimation, reading graphs and vectoring skills which are claimed for the package. Okey and Oliver (1986) are the first to admit that the reason for their being unable to detect any differences might be because their measuring instrument is not sensitive enough or because they are measuring the wrong things.

Another study, by Dicker (1984), systematically examined what students had learned from a series of programs modelling the ecology of a pond. In general, it was found that the greatest improvements in understanding of the ecology had come from those students who had well formed biological concepts to begin with. It was also found that presenting the simulation in a game format (maximising profits in a fish farm) improved students' attitudes to the simulation but interfered with their understanding of the ecology as they concentrated on improving their "score" on the game.

THE NEED FOR EVALUATIVE STUDIES AND RESEARCH

A major issue related to software evaluation is that relatively few evaluative studies have been conducted of the use of computers in education and of the learning outcomes of the different modes of educational software; there is consequently the need for many more such studies and research into what constitutes quality software. This need has been highlighted by Entwistle (1987b):

> "At present the evaluations that have been made of software and its uses stop short of detailed analyses of what pupils learn in using that software. Before we could develop teaching training programmes..., we need to have a more thorough understanding of what particular aspects of 'good practice' with computers lead to what specific gains in the quality of pupil learning. It is a worrying feature of most current evaluations of software usage that such information is not systematically obtained, leaving open the possibility that some of the programs are doing no more than keeping pupils entertained. It should be possible, in time, to give general guide-lines on the likely effects of different kinds of program, but we cannot do so with any confidence yet. There is an urgent need for systematic research into the learning outcomes of different modes of educational software. Combining such research evidence with reports on good practice in schools we could develop a better understanding of the potentialities of computers in the classroom, and so see the way ahead with greater clarity. It is crucial, however, to bring these two sources of evidence together in a more systematic way than happens at the moment".

Although many claims are made about the effect of such and such a piece of software, it is of concern that such claims have been confirmed by so few serious studies and that little research is being undertaken. This concern is shared by Jolicoeur and Berger (1986) who report that, surprisingly, there have been very few research studies. They attempted to conduct a meta-analysis on outcome studies of the educational effectiveness of individual software programs for microcomputers. As a first step, they sought to obtain a comprehensive collection of studies that measured the effectiveness of commercially available CAI. A literature search was conducted on ERIC (Educational Resources Information Center), *Psychological Abstracts* and *Dissertation Abstracts* up to mid-1985 and on a wide range of journals. Over 200 enquiries were mailed to researchers and institutions in the field requesting information on published and unpublished outcome evaluation studies that used microcomputers and commercial CAI. They received 63 replies, including many warnings that they would not be able to find any such studies. From all sources they were able to compile a list of only 47 outcome studies. Their proposed meta-analysis was consequently abandoned.

Bruce (1987) gives the following reasons for the lack of formal evaluation of software:

> "Software changes rapidly so that new versions appear in less time than one could carry out an evaluation of the existing version. Publishers, and even governmental research agencies, are often more interested in the next product than in analyses of existing software. Adequate evaluations are difficult, time-consuming, and expensive. Many

schools still do not have sufficient hardware for the necessary *in situ* studies. And, perhaps most importantly, new technology is never more than one component in a complex system that includes inter alia teachers, teacher training, existing curricula, school schedules and procedure, testing and maintenance of equipment".

If the true potential of the information technologies in the classroom is to be realised, ways and means must be found of providing for adequate research and evaluative studies.

Research is needed particularly in the following areas:

1. The effect of advances in the cognitive sciences, artificial intelligence and computer science on computer-based learning;
2. Evaluative studies of the use of computers across the curriculum, of the learning outcomes of the different modes of educational software and of how they can serve specific instructional needs; for example, the place of individualised drill and practice, motivational enhancement via educational games, educational simulations, and other educational tools such as word processing and access to databases;
3. The contribution of specific characteristics of educational software to its effectiveness;
4. The effective styles of classroom management using computer-based learning; the pros and cons of "electronic blackboard" programs, "group discussion stimulation" programs, "small group" programs and single user programs. How many computers are needed per class for efficient use of the technology? What is the effect on the attitude of teachers and pupils of the need to use a computer outside their own area?
5. The validity of reviews as measures of the effectiveness of educational software.

Chapter 5

THE TEACHER AND THE USE OF EDUCATIONAL SOFTWARE

All teacher training, whether at the pre-service or the in-service stage, should include training in assessing and selecting software. This should be part of the in-depth training in the pedagogical uses of the information technologies which teachers need to supplement the introductory training they usually receive in the operation of microcomputers and in their classroom use. If teachers were given such training, they would be able to convert the potential of computer-based learning into the actuality of instructional use which would meet their objectives and curriculum needs. In that context it is opportune to look at the use of computers across the curriculum from the teacher's point of view and to consider some of the issues involved in teacher training and support.

THE TEACHER'S POINT OF VIEW

A number of national reports have found that most teachers want to use technology in their classroom. Some reasons given are personal: the desire to develop professionally, to learn the newest tool of the trade, and to do their jobs better. Other reasons are centred on perceived benefits for their students: preparation for the world of technology outside school and a vehicle to channel their students' enthusiasm for technology into creative learning. Some teachers see the computer's potential as a tool for doing things they had been unable to do before, others the potential for providing different learning experiences for students. Some teachers are inspired by the new technology and their waning enthusiasm is rekindled; others quote new job opportunities and pressure from parents, schools boards and administrators as reasons for using computers; others are enthused by colleagues who use computers.

Not all teachers accept computers enthusiastically. Some fear students may lose old skills in adopting new ones, for example important underlying skills such as penmanship or computation, echoing Plato's fears in *Phaedrus* about the introduction of writing in ancient Greece:

> "Those who acquire it will cease to exercise their memory and become forgetful; they will rely on (it) to bring things to their remembrance by external signs instead of on their own internal resources".

Other teachers, not understanding the computer, fear it. Often knowing less about how the computer works than many of their students, they are frightened of not being the expert in their classroom, of embarrassing themselves in front of their students and consequently of their authority being lessened. They find that teacher/student roles and relationships are changed when students know more about the computer than they do, especially when some of them are given responsibility for helping to run the class and help other students. Some teachers cannot cope with this situation, whilst others welcome the opportunities.

The conclusion is clear. Many teachers are willing, eager and enthusiastic to use the new information technologies but they are unable to do so without training and support. The net effect on teachers is increased demand on their time and creativity. Whilst many teachers enthusiastically and willingly trade off this increased time for more excitement and challenge in the classroom and opportunities to expand their horizons, education authorities need to recognise the need for teachers to study on their own or in formal courses, to attend conferences and professional meetings and to explore and gain confidence in classroom use of the technology

TEACHER EDUCATION AND TRAINING

Although the importance of teacher education and training in the use of the computer is clear, unfortunately, to date, much of this training has not been very effective, and for a number of reasons. To quote the OECD Examiners to Norway (OECD/CERI, 1987b):

> "Experiences in many parts of the world show that much of the training of teachers about the use of interactive learning possibilities is ineffective. Only a very few locations do it well, mostly because of the presence of outstanding individuals in these locations. ... Inspection of programmes elsewhere shows a progression in (teacher training) courses. First, many simple modules teaching programming to teachers, usually in ineffective languages such as BASIC. A second stage focuses on computer literacy, emphasizing general tools, such as word processors. A third stage, seldom done adequately, has a pedagogical emphasis, stressing the use of computers in all subjects. The difficulties with this third stage stem from our lack of knowledge, and from our lack of sufficient adequate software to furnish examples of a variety of types of usage in a specific academic area".

The report of the International Seminar on Microcomputers and Secondary Teaching organised jointly by OECD and the Scottish Education Department (Scottish Education Department, 1988), for example, highlights the fact that, with the exception of France, the Nordic group and Scotland, only a small proportion of teachers in most OECD countries have been able to participate in in-service courses on the educational use of computers. The 1987 United Kingdom report on the Microelectronics Education Programme (MEP) found that most of the participants at MEP courses had been teachers with responsibility for information technology subjects in their schools and for passing on training to other teachers.

In Australia, an evaluation study of the National Computer Education Program has identified a similar situation and found that many of the courses given to teachers are not subject-specific but focus on computer literacy and the technology, the assumption being that once the teachers have experience in using computers, they will be able to address the higher-level issues of using computers in educationally useful ways (Bigum *et al.*, 1987).

The nature of the training which teachers require and the means by which they can acquire it are not so clear as the obvious importance of such training. This is partly because the advent of the information technologies has brought about complex changes in the role of teachers and the way learning is organised, partly because there has not been sufficient time to establish appropriate forms of training.

A number of documents and OECD seminars have identified competencies at three levels which teachers who are to use computers in the classroom ought to have, namely: the hardware, the software and the pedagogy levels (Poirot *et al.*, 1981; OECD/CERI, 1986). At the hardware level, there is the basic ability of operating a microcomputer and mastering ordinary techniques of entering data, etc., as well as the ability to set up and manage to the best advantage the hardware available in the classroom.

The second level is competence in the range of applications offered by the computer. This includes knowing and being able to use the various types of computer-based learning; of being able to identify the sources of appropriate educational software; of being able to use national and local computerised educational databases and communications systems to search for and obtain software; of knowing the criteria by which to evaluate software and being able to assess in educational and technical terms software which is relevant to their students' learning.

The third level is competence in the pedagogic use of computer applications. It is the conversion of the potential of computer-based learning into the actuality of pedagogic use and includes being able to integrate appropriate student use of computers and related devices into their teaching, whether in the laboratory, the classroom or the workshop; being able to evaluate their own use of the computer and to suggest ways of remedying weaknesses they discover.

Pre-service Professional Development

Despite the clear need to prepare new teachers to use computers, training in their use is a compulsory part of pre-service development programmes in only a very few OECD countries or parts of them. Examples can be given of the United States where pre-service training in the use of computers is required for teacher certification by 18 States and recommended by a further eight, but these are the exceptions, not the rule. A major effort therefore is still required on the part of OECD countries and teacher education institutions to ensure that pre-service courses adequately provide the training in the levels of teacher competence described above and include an element which enables future teachers to understand and investigate the way computers are being used and might be used in the curriculum.

It is of considerable concern that the delegates to the joint OECD-SED seminar referred to earlier could agree that "for the foreseeable future, pre-service provision is unlikely to make a significant contribution to the effective classroom use of microcomputers" (Scottish Education Department, 1988). The principal reason given for this assertion was that:

> "The most disturbing feature of our present stage of development is that it is the teachers themselves who are pioneering new approaches to practical pedagogy. ... knowledge about how these (computer-enhanced) environments work is only slowly being developed; it is being created at the classroom level by teachers who are acting as researchers, analysing the actual effects of different software packages, and experimenting with alternative ways of using them".

This perception, if correct, is an alarming indictment of the teacher education institutions, and, if incorrect, is indicative of the poor opinion some of the Seminar delegates have of the teacher education institutions in their countries.

It has to be recognised that teacher education institutions face a number of problems in trying to provide appropriate training for new teachers. Among them are deficiencies in hardware, software and materials and human resources. With regard to hardware, education faculties seldom seem to keep up with the rest of the campus when computing resources are allocated, nor do they receive the large equipment donations from hardware manufacturers which other departments do.

With regard to software and materials, courses must have a wide range of resources available to them. First, since they must expose teachers to what can be achieved by using the computer in that particular subject, a wide range of software must be available for the participants to explore and try out. Second, since the participants will wish to know what other teachers and reviewers think of the available software, there must be access to information sources including reviews about the software available. Third, since the aim is to integrate the computer into the curriculum, a range of curricular materials must be available, including, for example, lesson plans and guides showing how the particular piece of software can be integrated into the curriculum. Fourth, since everybody can learn from the example of others, descriptions of how the software has been used elsewhere can be extremely useful. Such descriptions might be in the literature; they might be provided by guest speakers or by the use of videotapes of classroom practice.

Teachers typically teach as they were taught. Consequently before we can expect trainee teachers to be technologically literate, the technological skills of teacher educators need to be upgraded. The lack of teacher educators with experience and expertise in using the computer across the curriculum and in giving courses about the use of the computer has, however, been identified by OECD studies as one of the reasons for the ineffectiveness of many teacher training courses in the past. Few education faculties appear to have sufficient teacher educators with the requisite experience.

The problem is exacerbated by the rate at which the technology continues to change and develop. As one dean of education has said:

> "The problem is how to prepare teachers for hardware that is not yet invented, for software that is not yet designed, and for curricula not yet imagined. It's hard to have a vision of what technology will be, but as deans, we have to have a vision, and we have to realise that it will change" (Carl Berger, in *Education and the Challenge of Technology*, 1986).

Teacher educators need at least the same competencies as the teachers they are educating and need to be aware of the latest developments in the use of computers. Since in some countries the practising teachers are the pioneers in the field, there would appear to be a need for greater co-operation between the teacher education institutions and the schools. It may be necessary, at a national level, to undertake the training of the teacher educators and to provide an ongoing programme of courses to ensure that the latest developments are incorporated in their courses.

The use of practising teachers, who have actually used computers in their teaching effectively as lecturers or as guest speakers on such courses, can be useful in generating discussion within the groups as to the advantages and disadvantages of using a particular strategy or software package, and the perceived changes within a classroom that have occurred or might occur.

Another practice from which considerable benefit can be gained is placing trainee teachers on their internships or practicums with computer-using educators and in this way providing them with role models for teaching with technology. Conversely, the student teacher who has learned at college to use the computer in his/her teaching can help to bring technology to the experienced teacher who has not previously worked with computers.

An issue related to teacher education institutions has been identified by the OECD Examiners to Norway (OECD/CERI, 1987b):

> "In many countries research into the pedagogical uses of computers has little status and brings low rewards in universities and academic circles. This leads to a small number of

people, who are not necessarily the most appropriate, in that area. If we wish to achieve progress it is necessary to change the state of affairs by recognising the value of this type of research. It will be necessary to alter university structures in order for research in this area to begin".

In-service Professional Development

Most current provisions for teacher training in OECD countries are in the form of in-service rather than pre-service training. The OECD/CERI report of 1986 has pointed out a major problem with this situation.

> "The new technologies carry implications for all subject areas across the curriculum, and at both primary and secondary levels. Given that the number of teachers at these levels who can reasonably claim to have received undergraduate training in informatics is negligible, we face the need to train, as rapidly as possible, the entirety of the teaching profession to use the new technologies. Given, again, the rapid evolution of the whole area, it is scarcely any exaggeration to say that the whole profession would need, by some means or another, to be placed in semi-permanent retraining. There are many reasons why it is wildly impracticable to think in these terms; not least, a lack of trained trainers, economic constraints, insufficiently clear agreement on the directions to be followed. The logistics of such an exercise, too, would be overwhelming. Yet this is, in fact, the fundamental task facing the various agencies of teacher in-service training and its seriousness should not be ignored".

The formal short course, whether centre-based or school-based, remains the principal means of in-servicing teachers in OECD countries. An OECD survey conducted in 1987 found that most Member countries provide in-service activities and that the combination of formal short courses and the *cascade* model of dissemination dominates.

Several types of courses are necessary. Evaluative studies conducted over a three-year period from 1985 to 1987 by the Minnesota Department of Education involving 17 technology demonstration centres and reported on by the OTA (1988), for example, have identified progressive stages of in-service work. These were characterised as:

- *Awareness* stage: large group workshops run to acquaint teachers with a general overview of how technologies work and to alleviate anxiety;
- *Overview* stage: workshops that delivered additional detail on how particular technologies work and usually provided examples of the application of technology to particular subject matter areas;
- *Topical* stage: a more focused approach (for example, using computers in social studies) with fewer participants;
- *Adoption/implementation* stage: more focused, with intense work by each participant;
- *Integration* stage: characterised by fine tuning of curriculum materials that use technology or guided assistance in integrating certain types of technology into a teacher's lesson.

The studies found that teachers preferred learning about technology from other teachers or from those who understand the settings in which they work. Teachers said they wanted access to follow-up support and access to equipment and software during and after the in-service training.

Other studies have identified a number of factors contributing to effective in-service computer education programs:

- *Appropriate balance between lecture and guided practice*: a cycle of mini-presentations, demonstrations and practice sessions appeared to be the most effective approach;
- *Detailed curriculum guides and lesson plans*: well planned materials were a visible component of the in-service programs;
- *Clear and relevant objectives*: teachers needed to feel they had a clear understanding of what they would learn and of their responsibilities;
- *Lesson-related materials and handouts*: such materials appeared to free teachers from extensive note-taking or reliance on computer manuals;
- *In-service lessons linked to instruction*: teachers liked specific help on preparing materials and experiences for their own students, things they could go back and use with their students the next day. Teachers appreciated and learned from good modelling on the part of the trainers;
- *Peer interaction*: communication among participants during hands-on sessions was particularly effective;
- *Strategies for teaching heterogeneous classes*: trainers who had ways to deal with students of differing levels of prior knowledge and anxiety were more effective. For example, some trainers used teaching assistants effectively in helping less or more advanced students;
- *Follow-up*: the impact of training was much stronger when followed up. Typically, teachers would come back together and report on their use of the computer application in the classroom, and share experiences (Stechner and Solorzamo, 1987).

In some countries the formal in-service training of teachers is being augmented by training through involvement in collaborative projects. Other forms of in-service activities have been devised which involve teachers as active participants in the process of integrating computer use in the curriculum, including action research activities, projects involving teachers in the design and development of software and associated curricular materials. For example, in Portugal joint projects have been established that involve teachers from schools and researchers and educators from the colleges and universities. In England and Wales the in-service focus is being placed on funding over 500 consultants to advise schools on the use of software to order to develop effective curriculum-related classroom learning and teaching approaches. In Canada, emphasis is being placed on resource persons who will assist and facilitate the use of microcomputers in schools.

A prominent feature of the joint OECD-SED seminar referred to earlier was a display of videotapes, which, it was agreed, provide a particularly valuable way of conveying the understanding gained from action research and demonstrating the changes in classroom management and interaction which are occurring. The seminar noted the need for banks of such video material, and the possibility of international exchange of videos was supported.

The magnitude of the problem of training teachers to use the computer across the curriculum and to find and use educational software should not be underestimated by education authorities. They should recognise too that the in-service training of teachers is an ongoing requirement. Attendance at a couple of in-service courses is not the end of the exercise; it is only the beginning. The training of teachers in the use of the computer is not a sort of one-shot vaccination or inoculation, which gives a lifelong protection and removes the need for further treatment. Teachers who have attended introductory courses will require follow-up training. The rate at which the technology, the software and the pedagogical applications develop also means that teachers will require further training on a practically continuous basis.

As steps towards that solution it is suggested that:

1. Where appropriate, OECD countries should conduct an assessment of the current facilities for training teachers in the integration of the computer in the curriculum. This should include both pre-service and in-service training, the experience and expertise of the teacher educators, the courses conducted and the resources available in terms of hardware, software and other resources;
2. As necessary, OECD countries should set up programmes to train teacher educators in the use of the computer across the curriculum;
3. In view of the continuing need to train new teachers in the use of the computer, OECD countries should ensure that the pre-service training of all teachers includes an appropriate programme of training in its use and that new teachers are competent in the use of the computer in their area of the curriculum;
4. Similarly, in view of the continuing need to train and retrain existing teachers in the use of the computer, OECD countries should set up national teacher education programmes in the use of the computer across the curriculum. Such programmes should include both in-service centre and school-based activities and should explore new ways of conducting such training, including the use of the information technologies themselves;
5. OECD countries should share information about the successes and failures of their training programmes with other countries.

TEACHER SUPPORT SERVICES

Support at the School or District Level – Computer Co-ordinators

A widespread phenomenon in many OECD countries, which is described in the report on *New Information Technologies* (OECD/CERI, 1986), is the emergence in schools or school districts of the information technology or computer co-ordinator. These are the "resource persons" who are knowledgeable about the use of the computer and to whom their colleagues can turn for advice. They help other teachers introduce the use of the computer into their pedagogy, find software for them, and in general advise them in the use of the computer. Their responsibilities include the management of the school's computing facilities and the development and provision of school-based in-service activities. They have to advise the school's management on acquisitions policy as well as educational development.

Often such co-ordinators have been the *devotees* or enthusiasts who have been largely responsible for the introduction of computers into their schools. Often they have been, at least initially, self-taught.

A number of issues arise regarding these resource persons. What training do they require, not just in the technicalities of the microcomputers and pedagogical applications but also in the inter-personal skills required to fulfil their function? How are they to keep up to date on the range of software which is available? How are they to cope with the extra work load which is imposed on them? What sort of recompense or recognition are they to be given?

Computer co-ordinators have been relied on extensively in the *cascade* approach to school-based in-service training. Unfortunately experience has shown that " ... the cascade model needs to be operated with extreme care, as it is all too easy for all the knowledge to cascade into a deep puddle in one person" (Griffin, 1988). For the approach to be successful co-ordinators need to be given time-release in order to fulfil their training role.

Another problem with co-ordinators is that, more often than not, they are the school's computing teachers, frequently with a maths or science background. Unless they personally have an exceptionally wide breadth of experience and knowledge, it is unlikely that they will be able to advise teachers on the educational applications of the computer for subjects other than their own. Yet another difficulty is that often such people have not been given any special training and have had the position thrust upon them.

Despite some problems, co-ordinators or resource persons can be extremely valuable assets in implementing the use of the computer and they need to be given support and recognition by the school or district.

Support at the State and Regional Level

The OECD report on *School Development and New Approaches to Learning: The Curriculum Redefined* (forthcoming) highlights the need for professional development and support services when major curriculum developments, such as the integration of the use of the information technologies into the curriculum, are being undertaken.

> "Fortunately, in most countries, curriculum development has never been isolated from professional development, most particularly through in-service education programmes for teachers and principals. A common pattern of development consists of the production, through a commission or government department, of a broad curriculum plan. This may be for the whole curriculum or for a subject area, such as, in recent times, computing in schools. If adopted, this plan is followed by a programme of conferences and training sessions for practitioners, to ensure that the plan is adopted. ... all too often that stage is abbreviated and seldom are teachers involved. ... unless follow-through is rigorous and extensive, adoption is likely to be partial. Resources on a very considerable scale are required, not only for equipment and materials, but for consultancy and support services and for staff development".
>
> Project-based curriculum development requires services and support which include:
>
> " ... adequate staffing at centre and periphery; expertise in network schools; adequate provision for staff development and project evaluation; real potential for mainstream adoption. Such an approach is commendable, but it requires a range of services, which are costly" (OECD/CERI, forthcoming).

Support services have been provided in some countries. In the United States, for example, California was an early initiator of the concept of regional Technology Education Computer (TEC) Centers to provide a network of resources for training and technical assistance across the state. Seventeen centres were established to co-ordinate support services for teachers and schools. Despite the major support role played by the centres, however, the state budget of 1987 discontinued funding for them. In contrast, the New York State's Teacher Resource and Computer Training Centers have expanded dramatically. The original centres were created in

1984 to improve teaching skills and train teachers in the educational applications of computer technology. In 1987 state funding was increased from $12.5 million to $15 million to support the existing 74 centres and add 17 new ones. The centres are linked electronically, enabling teachers to communicate from one centre to another, either informally on electronic bulletin boards, or more formally in computer conferences, on topics of shared concern. In addition to the centres, many other state units and teacher education institutions offer programs of technology training.

In Australia, a number of such support centres and consultancy services were established with Commonwealth funding as part of the Computer Education Program of 1984-86. Unfortunately with the end of the Program, funding for many of the centres ceased and was not replaced with state-based funding. The work of one such centre, the Non-Government Schools Computing Centre in Western Australia, is described in the evaluative study, "The Commonwealth Computer Education Program in Non-Government Schools in Western Australia" (Straton and Toussaint, 1988). The report indicates that the schools relied heavily on the expertise, resource library, professional development and support facilities provided by the centre. It was clear that, the more exposure and experience teachers had with the use of educational software across the curriculum, the more they wanted and that the centre had achieved its aim of overcoming teachers' lack of knowledge and confidence. Fortunately, despite severely reduced funding, the centre continues to operate.

Although the OECD report on the Curriculum Redefined (forthcoming) referred to above concerned support services in general, the following comment is particularly appropriate with regard to the integration of the information technologies into the curriculum:

> "It is a matter of concern that such services are being reduced in many countries, just at the time when governments are promulgating large-scale reform. Australian state systems of education, for example, have all suffered substantial reductions in consultancy and support services. Yet major restructuring is occurring, including devolution to schools and school communities of responsibilities previously exercised by central authorities. ... neither the curriculum branches of the state departments nor the Commonwealth Government's own curriculum development agency is being strengthened to cope with these requirements".

Software Previewing Centres

A number of the support services required by teachers relate specifically to software. Teachers need access to information about software, to reviews of the available software, and to the software itself so that they can see whether it meets their requirements. The availability of such services is essential for a systematic approach to the assessment and selection of software.

Many of the issues involved in the dissemination of information and in the production of reviews have been discussed in Chapter 4. In some countries, the facility of previewing software has been provided by the evolution of software preview collections in teacher training or resource centres. Since such collections need to be within easy access by a large number of teachers, they are usually set up on a regional, state or province basis within large centres of population. A number of strategies can be used to make such software collections accessible to schools and teachers who, because of distance, are unable to visit the centre. They include, for example, the use of postal and courier services and visits to schools and local centres by the staff of the preview centres to demonstrate the latest software available at the centre. The use of telecommunications to broadcast the software is also a possibility. The distribution of public domain software, for example, has been explored in the United Kingdom. In the United States, the Los Angeles Unified School District has installed a system called the *Electronic Software Delivery System* (ESDS), which allows teachers all over the district to access and preview software. A security device prevents illegal copying or use of the software. The system also keeps a record of those who access a program, how many times they access it and for how long. There are advantages to be gained from having such resource centres combined with in-service centres and located at teacher education institutions, rather than as separate resource centres, since experience has shown that teachers will use such centres more frequently if their visits can be combined with attendance at an in-service or a higher education course. Such resource collections are an indispensable part of in-service training in the use of computers across the curriculum.

A number of issues arise regarding such centres. How should they be managed? What is the role of schools in the process? What safeguards should centres have against the illegal copying of software? Should software be loaned to teachers? Under what terms? How should software publishers support such centres?

Teachers and software publishers share a problem regarding the circulation of educational software for preview. Software publishers cannot be expected to supply every teacher or even every school with inspection copies of every software package in the same way they supply inspection copies of textbooks on a *sale or return* basis. Preview centres offer educators the opportunity to preview software without spending money and offer software publishers the opportunity to make available reasonable numbers of products for preview by large numbers of educators.

As an aid to decision-makers, educators and software publishers, the *Software Resource Center Committee* of the International Council for Computers in Education (ICCE, 1987), in co-operation with directors of large resource centres in North America and publishers, canvassed, during 1986 and 1987, the views of teachers regarding such resource centres. As a result, it has developed a policy statement, which is actually a set of guidelines for the operation of Software Preview Centres, defining the responsibilities of the three parties involved, namely, the resource centres, the software publishers and the schools.

The software resource centres should serve as valuable links between software publishers and educators. They should have policies on software copyright, previewing and loans of software, staff who can assist educators in using the software, hardware on which educators can preview the software, a system for disseminating information about software and training programmes for educators. For their part, software publishers should assist educators in the preview of instructional software prior to purchase by working with the software resource centres. Schools too have their responsibilities: they should encourage preview of instructional software prior to purchase and they should be willing to sign a required statement regarding protection of copyright of the programs previewed (ICCE Software Resource Center Committee, 1987a).

Support at the National Level

Since OECD countries have policies with widely different degrees of central control over education, an important issue with regard to the development of the use of the information technologies in education is the balance between centralised and decentralised activities. In a number of countries, national programmes and initiatives have been established to develop the potential of the information technologies. In countries where responsibility for education is vested in the local or state authority, such programmes have often been seen as complementing those of the local or state authority or as *seeding* programmes.

The International Seminar on Policies and Strategies for Introducing Computers in Schools organised jointly by the OECD and the Norwegian authorities in February 1988 highlighted a number of reasons for central or national approaches, including:

- Since the introduction of microcomputers into schools is a permanent change to education and not a temporary feature, there have to be national approaches which give central responsibility for initiatives, guidance and monitoring;
- Too rapid a decentralisation of control could increase the risk of losing momentum, of broadening and blurring the focus of a national strategy with a subsequent loss of quality of design and implementation;
- A central reorganisation of the curriculum could facilitate the incorporation of the information technologies and the required changes in school organisation.

Perhaps the most cogent reason for continued national support was expressed by the OECD/CERI Examiners to Norway (1987b) and :

> "The development of the computer as an effective aid in education is still fragile. Although the potential is great, for all countries, the development needs special assistance at the national level if it is to be effective".

The United States OTA report (1988) concluded similarly that:

> "The Federal Government must take an active role if interactive technology is to realise its potential for improving education. National needs for educated citizens and workers, combined with traditional Federal responsibility for equity, are the underpinnings for Federal action. Further, the centrally important aspect of research will be adequately supported only as a national undertaking at the Federal level".

In the context of this study, it appears that OECD countries would benefit from the establishment of national centres for the development of the use of information technology in education. A number of OECD countries, or states or provinces within OECD countries, have established such centres, including the Microelectronics Education Support Unit (MESU) in the United Kingdom, the National Software Co-ordination Unit (NSCU) project in Australia, the Centre for the Study of Systems and Advanced Technologies (CESTA) in France and the San Mateo Microcomputer Center in California. Not all have the same functions, and, unfortunately, not all are still in operation. Among their functions are:

1. The provision of information and advice on information technology matters to policy-makers;
2. Acting as a national clearinghouse of information about software, reviews, evaluations and research and making such information available to teachers through the regional resource centres;
3. Publishing or commissioning publications on the various existing pedagogical strategies implemented in software (tutorial, drill and practice, simulations, microworlds, etc.) and on the various existing strategies and techniques used to develop software;
4. Acting as a base for software development;
5. Acting as a focus within the country for research into all aspects of the use of educational software across the curriculum by commissioning research and providing a research clearinghouse;

6. **Reviewing and evaluating educational software or commissioning reviews and evaluations of educational software;**
7. **Maintaining links with international organisations and similar organisations in OECD countries.**

Chapter 6

MAIN CONCLUSIONS OF THE INTERNATIONAL SEMINAR ON SOFTWARE REVIEW AND EVALUATION

In October 1988, fifty-five national representatives and experts from twenty OECD countries attended the International Seminar on Software Review and Evaluation: Trends and Issues held at OECD Headquarters. The Seminar participants discussed the major issues raised in this study whose objectives were:

- To provide new information regarding educational software review and evaluation mechanisms set up in OECD countries;
- To clarify and discuss the issues related to the review and evaluation of educational software;
- To discuss the possibility of international co-operation in the area of educational software review and evaluation.

The following conclusions, based on views expressed during the Seminar, represent the participants' opinions on a number of key issues related to the review and evaluation of educational software. Many other important, but more specific, points could not be dealt with during the two-day meeting.

First Conclusion: *We cannot afford not to provide teachers with information about available teaching and learning software.*

If we want teachers to use software effectively in their teaching, information about existing software must be made available to them so that they can select the software appropriate to their needs. One view expressed was that teachers should be provided with the best possible "software description" (see Chapter 4 for clarification of the various terms used: "description", "review" and "evaluation"); they should be given appropriate training and be allowed to decide for themselves what software meets their needs. Several participants suggested, however, that such information by itself is insufficient. One does not buy a product such as a car or go to the theatre without having first obtained, not only a certain amount of information about the product, but also advice and critical reviews about it. Many participants therefore agreed that teachers need more than just objective descriptions of the software and that software reviews and evaluations containing evaluative comments are needed.

The expert from the United States expressed a number of concerns about the information needs of teachers. They need information not just about software in terms of its existence and quality but also about how it can be used in the classroom. Their needs are dynamic and constantly changing and evolving. Time is the significant barrier for teachers who, as more and more information becomes available, are drowning in information. Moreover, it is important to recognise that they are not just recipients of information but also contributors to it.

> ***Second Conclusion:*** *Although opinions apparently differ, there is in fact a broad degree of agreement on the feasibility and value of review and evaluation of educational software.*

In any international gathering there will always be differences of opinion due to barriers of culture and language which are more apparent than real. This is especially so when the same terms have different meanings for different authors and speakers and in different countries. This was the case at the Seminar with the terms *software review* and *software evaluation*. Despite the difference of usage, however, it is clear that there was a broad underlying level of agreement.

In the past a measure of objectivity has been claimed for *software reviews* conducted by trained reviewers, especially for reviews which are consensus statements. However, it is now generally accepted that since they are made in the context of the value system of the reviewer, such reviews are by nature subjective and there can be as many different reviews as there are reviewers. This view was particularly evident at the Seminar.

The view was expressed that it might be possible to provide opinions which, no matter how competent or trained the reviewers are, would be totally subjective. As *one of the experts from France* pointed out, it would be necessary to know what *subjectivities* were behind these *objective opinions*. It might be possible to appraise teaching software, that is, tools designed to aid the teacher in presenting, explaining and testing, but it would be unrealistic in the case of learning software such as simulations, exploration-discovery programs, robots, etc., involving a dialogue between teacher, student and computer. The teacher has methods and strategies but, as *the delegate from Portugal* noted, so does the student and we know little about the impact of the various degrees of interactivity provided by the computer. *The delegate from France* clearly stated his position: give teachers the best possible factual information (description), provide them with appropriate training and allow them to decide for themselves what software meets their needs, what is good and what is not. *The expert from Belgium* suggested that software review made sense only in terms of the buyer's goal. It was also pointed out by *the Canadian delegate* that in certain federal countries a centralised review or evaluation scheme is not appropriate because of the diversity of educational objectives and curricula, Canada, for example, having ten provinces with ten different curricula. Despite their drawbacks and shortcomings, however, many participants considered that such software reviews can be very useful guides to teachers in making their decisions regarding the selection of educational software.

A number of countries, including *Belgium, Denmark* and *the Netherlands*, supported the position that *software evaluation*, using various observation and measurement techniques to examine the teaching/learning activity in the classroom from different angles, is possible and desirable; this is true research work involving teachers, students and researchers. However, since it is very time-consuming and costly, they thought that it should focus on a selection of the better products, perhaps those identified by means of the various reviewing mechanisms in use. Several participants, including those from *the Netherlands, Portugal* and *the United States*, were interested in the impact of this type of evaluation on the development of improved software prototypes. *The delegate from France* pointed out that there are many reasons why evaluating software is difficult, just as in evaluating anything in education, but despite the difficulties, everyone agrees that we need to evaluate.

The view expressed by *the delegate from the United Kingdom* was that neither software reviews nor software evaluations are important since it is how the teacher uses the software in the classroom that counts. In order to come to a better understanding of the computer's impact on learning, there is a need for classroom observations of effective uses of software integrated into the curriculum. There is consequently no *good* or *bad* software. Some uses are effective and others are inappropriate; some teachers are clever and others not so clever; some environments are favourable and others are not. As the *delegate from Canada* pointed out, however, "the merits of a piece of software and the merits of its use in the classroom are two very different things".

***Third Conclusion:** There is a continued need for agencies and mechanisms to provide information about the quality of software to teachers.*

The participants explained how information about software has been provided in their countries in the form of printed catalogues or electronic databases. Some of the countries – Australia, Canada, France, United Kingdom, United States – have had considerable experience in this area. Others, Dutch-speaking Belgium, Germany, the Netherlands, Norway, have recently set up reviewing agencies or are about to do so. Still other countries, such as Turkey, are now planning for the widespread adoption of computers in schools. Unable to provide for the development of software, these countries emphasize the importance of having access to information about software in other countries so that they may use the programs which are appropriate and adapt others to their social and cultural needs. The Luxembourg Ministry of Education considers that, given the country's size and its limited resources, the creation of an infrastructure for software development cannot be justified at this time. As the country is consequently highly dependent on products developed by other countries, the review and evaluation of software are important aspects of the national programme for introducing the new information technologies into education.

A number of the agencies are part of larger operations providing support services to schools and teachers where software review and evaluation and the provision of information are seen as integral parts of those services. Other services provided include the professional development of teachers and the provision of resource or preview centres which by various strategies enable teachers to view the available software and curriculum materials in order to evaluate them for use in their own schools. Some agencies are actively involved in the development of software or in advising developers of software; they conduct formative evaluations in order to assist the software developers as well as summative reviews and evaluations to assist teachers.

In some countries providing teachers with information about software is considered an integral part of the provision to teachers of curriculum information in general. In these countries special agencies have not been set up to review and evaluate software, and information on the use of the information technologies is provided alongside information about the use of curriculum materials in the more traditional media such as print, audio and video.

A view expressed was that in the long term many of the functions and roles of the software review and evaluation agencies will be subsumed into the functions of agencies providing information about curriculum materials in general, such as national or regional curriculum centres and professional subject associations. It was agreed, however, that whilst in the long term such software review agencies may be seen as temporary phenomena catering for the immediate pressing needs of teachers, they currently provide a very useful service. Taking into account the current state of development of the use of the information technologies across the curriculum, the continued existence of these agencies would appear to be useful for at least the foreseeable future and consequently they need to be funded at an appropriate level.

***Fourth Conclusion:** Teachers need training in the selection of software as well as prior training in the pedagogical uses of computers.*

After considering many of the issues related to software review and evaluation and the dissemination of information, the participants agreed that the training given to all teachers, whether at the pre-service or the in-service stage, should include training in assessing and selecting software. This should be part of the in-depth training in the pedagogical uses of the information technologies, which teachers need to supplement the introductory training they usually receive in the operation of microcomputers and the setting up and managing of the hardware available in their classrooms. If teachers were given such training, they would be able to translate the potential of computer-based learning into the actuality of instructional use which meets their objectives and curriculum needs. Participants agreed on the necessity of such training but were concerned about the numerous problems involved in the training and support of teachers, for example, the lack of appropriate training, the lack of time, the lack of suitable teacher educators and the lack of appropriate support services.

If teachers were properly trained, they would then be able to use available reviews to select appropriate software for teaching and learning. They would go through the following process:

- The determination of software needs and the specification of software requirements. This should follow an assessment of curriculum needs so that the software is selected to fit the curriculum, rather than making the curriculum fit the software.

- The identification of promising software through searches of appropriate sources. The usual means of identifying software are: publishers' catalogues, journals and reference manuals, consultation with colleagues, computer education consultants and subject associations; access to appropriate electronic databases is another source of information. In this connection *the delegates from Canada and the United Kingdom* emphasized the importance of user-friendly databases. The latter also explained that, in the United Kingdom's experience, if access charges and communication costs were significant, teachers would not use databases. *The expert from the United States* expressed the view, supported by many participants, that "teachers want information, but they are not prepared to pay for it". There was significant support for the storage of databases on CD-ROM for distribution to schools. In the United States, networks and conferencing are used by the teachers themselves to share information. In France, the public viewdata system, Minitel, is used to provide information to teachers not just about software but about all aspects of their professional life. *The delegate from Japan*, however, thought that on-line databases and CD-ROMs were a dream at this point in time of developments in his country.

- The reading of relevant reviews and case studies of the use of the identified pieces of software. This can help to reduce the list of software that warrants further examination.

- The previewing of the software by both teachers and students. Even though reviews can help, the conscientious teacher selecting software still needs to preview software before purchasing it. In the final analysis teachers still have to look at the software for themselves and decide whether a particular package is useful to them. The participants described preview centres set up at the local and regional levels (Canada and France, for example), while at the same time emphasizing the advantage of using telesoftware so that teachers do not have to travel to the centres (United States and United Kingdom). Ingenious security schemes have been developed to deter the duplication or unauthorised use of telesoftware.

- Finally, the selection of the most appropriate software.

Fifth Conclusion: *There are opportunities for international co-operation in the review and evaluation of software and in access to educational software.*

Many participants clearly perceived that co-operation in a number of areas could greatly benefit OECD countries in realising the full potential of the information technologies.

Although the diversity of curricula, cultures and languages among countries would appear to preclude close co-operation in the actual reviewing and evaluation of software except among countries with close geographic, cultural or language ties, there does appear to be the need and opportunity for much more sharing of information than is currently taking place among agencies at the international level. As *the participants from France, Norway* and *the United States* pointed out, co-operation does exist, for example between the United States and Canada, between Québec and France, and within the Nordic Council. Many of the participants expressed willingness and even eagerness to share information.

Thus, in the first place, there is a pressing need for research and experimentation in areas related to a number of issues discussed in this study, and the information gained from studies conducted by the OECD countries could be shared with other countries. In this context *the delegate from Canada* suggested that OECD could undertake the production of a bibliography of research findings. Similarly, in view of the costs and of the waste involved in the duplication of effort, it would be advantageous for OECD countries that are developing databases to explore ways of sharing their data and, where appropriate, to incorporate data from other countries' databases into their own. The data could include not only descriptive information but also evaluative comments and curriculum notes. *The delegate from Belgium* suggested that OECD could organise a working party to define standards for databases.

Access to a number of databases, including the NERIS (United Kingdom), York University (Canada), RICE (United States) and SCOR (Australia) databases was offered at the Seminar. In some cases the sharing of data was offered within the context of an international exchange programme, and it was also suggested that it might be possible to access the databases of various countries through the software library (*Logithèque*), to be housed in the "biggest library in the world" in Paris, France.

It was also suggested that OECD countries could explore mechanisms for co-operation in the development of an international database containing information about each Member country's high quality educational software. Copies of both the database and the software could be made available to other OECD countries. Such a database could be a useful means of keeping up to date on the best software in other countries which might be worth considering for adoption or adaptation. There appeared to be consensus regarding the sharing of software descriptions but not of software reviews or evaluations. Many participants pointed out the difficulties and dangers of attempted co-operation in these areas. *The Danish delegate* thought that a unified OECD theory of evaluation was inoperable; however, he thought it would be useful for OECD to set up formative evaluation projects to be carried out by two or three countries and that Denmark could learn much through international co-operation in summative evaluation projects. *The delegate of the United Kingdom*, however, was not convinced of the usefulness of involving several countries in such evaluation. In his view, the co-operation of three EEC countries, Denmark, the Netherlands and the United Kingdom, in the design of a software program proved to be more enriching than an exchange of evaluation findings.

Sixth Conclusion: *The quality of software depends on a number of interrelated, evolving variables; the quality of software, its review and evaluation should therefore be considered in the light of past and future developments.*

The Seminar Chairman, *Pr. J. Hebenstreit of France*, emphasized the importance, when discussing a topic such as software review and evaluation, of "references to the past which explain the present and references to the future which allow us to put things into perspective..." Twenty years ago some evaluators considered drill and practice software to be of high quality, whereas this same software is today treated as *junk*. This is because the concept of quality in software is evolutionary, due, first of all, to progress in technology, which has led to new uses of computers in education and to an increase in the number of computers in schools, and, secondly, to progress in the cognitive sciences which has opened new perspectives in the understanding of the learning outcomes of various instructional strategies.

Participants mentioned other variables determining the quality of software such as: design features, curriculum relevance, teaching style and resourcefulness of teachers, and learning style, each of which affect one other in varying degrees. *The delegate from Italy* considered that review and evaluation can also be dependent on the culture and the context in which they are conducted and on the evaluator who conducts them. *The delegate from Portugal* pointed out that good teachers use different strategies, and that there are also different strategies of learning which must be taken into account when reviewing or evaluating software. *The United Kingdom delegate* put the emphasis in judging software on the learning process, not the teaching process, and stressed the existence of essential national and cultural differences in software. Participants saw the concept of quality in software as an evolutionary one.

Looking to the future, *Pr. J. Hebenstreit* projected that in the next ten years every student will have a pocket computer. This would imply radical changes in the use of computers in schools and a radical change in the software market: it would become a mass market in which successful programs would sell by the millions. Hardly a textbook would be published without a set of programs offering a wealth of examples, drill-and-practice exercises, simulation activities, relevant databases, interactive concept exploration and hypothesis testing, all organised and planned in keeping with an instructional strategy complementary to the content of the book. In the classroom as well as at home, students would be able to make rapid calculations, check the validity of a formula, look up statistics, review a lesson, type a report, take notes, communicate with other students or teachers. Today teachers decide what software is to be used at a given time. In the near future children will be using all kinds of software with or without the teachers' permission and will in fact create a software market which does not exist today.

In this context, what will software evaluation mean?

We should use our past experience with pocket calculators. Because they had not kept abreast of rapid technological developments in this area and were unaware of the implications of the rapid drop in cost and widespread use of calculators in society, numerous decision-makers and teachers found themselves in a difficult position. We must keep in mind that the children entering school today will still be in the compulsory education system in the year 2000. We are, *the Chairman emphasized*, right in the midst of a transitory period and the most radical changes are still to come. "The wisest thing to do, therefore, is probably to try to build a reasonable view of what is coming and to use every area which we can act upon (teacher training, research, evaluation) to prepare our educational system as well as possible for the inevitable changes which lie ahead".

The participants agreed on the importance of preparing for the future although they did not all agree with many of the more radical prognostications which are often made. *The delegate from Spain*, for example, observed that the death of schools had often been predicted but they were still there. It is clear, he said, that the role of teachers is not highly regarded since everybody thinks they can make pronouncements on the future of education. He was certain that the need for the assessment of quality in software would remain. Others felt that a mass market in educational software would reinforce the need for mechanisms for software review and evaluation and the need for governments and education authorities to support initiatives in the area. *The delegate from France* suggested that the OECD should establish an institution for co-operation between countries to pull developments together. *The delegate from the Netherlands* noted that to date the use of computers in education had been driven by the technology. We need now to rethink education with technology as a factor. A number of examples were also given of work being done in various research centres, especially in the area of artificial intelligence.

EPILOGUE

The potential of the information technologies to change education is well documented. Although research and experience give an incomplete and impressionistic picture, they show that the information technologies could have a profound impact on the learning process, on the content of courses, on the role of the teacher and on school and classroom organisation. The present study has discussed a number of issues involved in this potential change, specifically those related to the problems teachers face in selecting appropriate software for use across the curriculum. A number of general conclusions can be drawn related to software review and evaluation, international co-operation in the field and the policy implications of the use of the information technologies.

SOFTWARE REVIEW AND EVALUATION

The study has highlighted many of the factors which inhibit and prevent the optimal utilisation of the information technologies. Many of them relate specifically to software and include the lack of quality software, the lack of access to reliable information about software, the lack of adequate training and support for teachers in the use of software as well as the lack of hardware in some schools and the lack of commitment on the part of some education authorities. The study has identified the means of removing many of these inhibitors. All commentators and the participants of the October 1988 Seminar are agreed that teachers must have information about available teaching and learning software, that the review and evaluation of educational software is valuable to teachers, that there is a continued need for agencies and mechanisms to provide teachers with information about the quality of software and that teachers need training in the selection of software as well as in the pedagogical uses of computers.

The evidence, however, of what is actually happening in many countries to provide for these needs is not very encouraging. Information about available software is generally not easily accessible to teachers or, for a number of reasons, is not used, even when databases have been created specifically for this purpose. Agencies have been set up to review software but even now they are unable to keep up with the flood of software becoming available and to provide teachers with the critical appraisals of software they need. Not all such agencies continue to survive. A common leitmotiv running through the account of activities in OECD countries is of projects and agencies being left without continued funding, like so many ships left stranded on the beach when the tide has gone out. Both pre- and in-service training to date has been largely unsuccessful in meeting the needs of teachers for training in the selection of software and its use across the curriculum. Support services, including the provision of software previewing facilities for teachers, are often largely non-existent.

With the present level of resourcing, what will happen when, as has been suggested, students all have pocket computers and there is a mass market for software which is readily available in every subject area and at every age level? Undoubtedly, the needs of teachers for accurate information and reliable appraisals will be magnified and largely unmet; the surviving agencies will be totally submerged by the deluge of software of questionable educational quality and few teachers will be proficient in the use of the information technologies in the classroom.

> *A clear conclusion therefore is that without increased funding of software reviewing agencies by governments and education authorities, the needs of teachers for reliable information and appraisals of educational software will not be met.*

INTERNATIONAL CO-OPERATION

Previous OECD studies have highlighted the need for co-operation among Member countries in the use of the information technologies in education. Thus the OECD conference of 1984 reported on in *New Information Technologies: A Challenge for Education* in particular recommended international co-operation in the establishment of standards for software and hardware production as well as for cataloguing, describing and evaluating software for authoring systems, software tools and graphics (OECD/CERI, 1986).

Similarly, the Working Groups of the 1986 OECD Conference on *Information Technologies and Basic Learning: Reading, Writing, Science and Mathematics* recommended:

> "There should be demonstration and evaluation centres at which software and other technologies can be compared, where results from different countries can be evaluated, and where long-term development efforts can take place with the co-operation of researchers, software designers, and teachers from different countries. International centres of this sort would also facilitate exchange among countries with very different experiences and levels of development in the use of the information technologies..." (OECD/CERI, 1987a).

The same conference suggested international co-operation and information sharing about projects examining basic skills education and research in the cognitive and instructional sciences.

As has been seen, the participants of the October 1988 Seminar also made a number of suggestions regarding possible international co-operation.

An international software clearinghouse could provide the mechanism for such co-operation. Although intended primarily for the benefit of OECD participating countries, the clearinghouse could also service other countries, particularly those of the Third World, and higher education institutions. It could have the following functions:

1. The identification of research activities in participating countries in the area of computer-based learning and the dissemination of information about such research;
2. The identification of innovative approaches for teacher training and for the training of teacher educators and the dissemination of information about such activities to other countries;

3. The creation and maintenance of a database of information including reviews, evaluative studies and case study material about the best quality software produced in participating countries and making it available to the other countries;
4. The liaison with national centres;
5. The exploration of the possibility of establishing standards and mechanisms for the co-operative development of educational software;
6. The facilitating of information sharing by means of electronic networking between educators regarding the use of the information technologies;
7. The exploration of the possibilities of the exchange of software among countries;
8. The liaison with higher education institutions and organisations with regard to the use of the information technologies.

A clear conclusion is that there are advantages to be gained by countries setting up mechanisms which, while respecting national and cultural differences, foster international co-operation in the area of the information technologies in the curriculum.

GOVERNMENT SUPPORT OF THE INFORMATION TECHNOLOGIES IN EDUCATION

A number of countries have conducted evaluations of the developments in their countries. Australia (1987), England (1987), France (1986), Norway (1987), Scotland (1987) and the United States (1988), for example, have published interesting evaluation reports dealing mainly with the various ways computers may be used in the teaching/learning process and highlighting their potential.

Governments and education authorities, however, cannot be expected to be committed and to provide funding for second wave computer acquisition projects as follow-up to the programmes implemented in many countries during the years 1982-86 that were based only on the *potential effectiveness* of computers. There is therefore a pressing need for the *real effectiveness* of the information technologies to be demonstrated by building on the experience of schools which have reached the critical mass in terms of access to computers, quality curriculum-integrated software and teachers trained in the pedagogical uses of the computer.

Many countries feel that responsibility for the type of research and development needed comes within the ambit of the national or federal authorities. As reported at the October 1988 International Seminar (see Chapter 6), some countries are taking steps to address the issue. Sweden, for example, which up to the present had been following a *restricted* policy of emphasizing teaching about computers, is planning "a three-year project on the use of computers as a pedagogical aid" in a "limited number of schools". The United Kingdom, which has followed a *comprehensive* policy encouraging both teaching about computers and the use of the computers across the curriculum, has created a unit within the Department of Education and Science to supervise "a major policy-oriented research study to provide firm and consistent evidence of the effectiveness of the use of Information Technologies as teaching and learning resources".

Some of the lessons to be learned from experiences in a number of OECD countries are very clear. The use of computers across the curriculum appears to be a chicken-and-egg situation. Further development in the use of computers across the curriculum will not be supported by governments and education authorities unless there is clear evidence of the potential being realised. The potential will not be realised, however, unless adequate hardware facilities are provided to schools; unless teachers have access to quality software which meets their curriculum needs; unless there are adequate support facilities for teachers and unless teachers are given appropriate professional development. But these facilities will not be provided by governments and education authorities until there are tangible results to be seen from using computers across the curriculum.

Many of the measures which governments might take have been mentioned in this study. They include the provision of training for teachers at both the pre- and the in-service level, software reviewing agencies, information dissemination mechanisms, software preview facilities, research and development. In many countries some of these measures have been provided on a short-term basis by special programmes. As with most educational innovations and developments, however, concrete results will not be seen without long-term commitment by teachers, schools and education authorities. It is therefore to be hoped that governments and education authorities will see the need for appropriate measures and programmes to provide these facilities on an ongoing basis. Without that top-down intervention, it is very doubtful whether the chicken will be able to hatch itself.

> *A clear conclusion therefore is that, if governments and education authorities are not committed to taking appropriate long-term measures, the potential of the information technologies to improve education will not be realised.*

LIST OF ACRONYMS

ALE	"Apprentissage de la Langue Écrite" Project, France
ANTEM	New Technologies Applied to Education, Professional Training and Culture
ASCIS	Australian Schools Catalogue Information Service
BSD	Biblioteca del Software Didattico, Italy
CAD	Computer-Aided Design
CAI	Computer-Assisted Instruction
CAL	Computer-Assisted Learning
CAMIF	Coopérative des Enseignants et Personnels de l'Education Nationale, France
CBL	Computer-Based Learning
CESTA	Centre d'Etudes des Systèmes et Technologies Avancées, France
CET	Council for Educational Technology, United Kingdom
CITE	Centre for Evaluation of Information Technology in Education, United Kingdom
CLEO	Centre Lorrain d'Enseignement Assisté par Ordinateur, France
CMEC	Council of Ministers of Education, Canada
CML	Computer-Managed Learning
CNDP	Centre National de Documentation Pédagogique, France
DES	Department of Education and Science, United Kingdom
EAO	Enseignement Assisté par Ordinateur
ECC	Educational Computing Consortium B.V., the Netherlands
EPIE	Educational Products Information Exchange Institute, United States
ESDS	Electronic Software Delivery System, United States
FCIC	Florida Center for Instructional Computing, United States
FIRN	Florida Information Resource Network, United States
ICAI	Intelligent CAI
ICCE	International Council for Computers in Education, United States
IIIR	Integrated Instructional Information Resource, United States
ILS	Integrated Learning System
INRP	Institut National de Recherche Pédagogique, France
IPN	Institute for Science Education, Italy
ITS	Intelligent Tutoring System
MAPE	Microcomputers and Primary Education, United Kingdom
MBI	Microcomputer-Based Instrumentation
MBL	Microcomputer-Based Laboratory
MEP	Microelectronics in Education Programme, United Kingdom
MESU	Microelectronics Education Support Unit, United Kingdom
MicroSIFT	Microcomputer Software Information for Teachers, United States

NCEP	National Computer Education Program, Australia
NCET	National Council for Educational Technology, United Kingdom
NCTM	National Council of Teachers of Mathematics, United States
NEA	National Education Association, United States
NERIS	National Educational Resources Information Service, United Kingdom
NFER	National Foundation for Educational Research, United Kingdom
NSCU	National Software Co-ordination Unit, Australia
NSTA	National Science Teachers Association, United States
OSE	Ordinateur au Service de l'Education, Belgium
OTA	Office of Technology Assessment of the Congress of the United States
RICE	Resources in Computer Education, United States
SCEN	Software and Courseware Evaluation Centre, the Netherlands
SCOR	Schools Computing On-line Resources, Australia
SECTOR	Special Education Computer Technology On-line Resource, United States
SED	Scottish Education Department
SEED	Software Evaluation Exchange Development, United States
SUGAR	Software User's Guide to Available Resources, Australia
TECC	Technology Education Computer Centers, United States
TECC	Texas Education Computing Co-operative, United States
TESS	The Educational Software Selector, United States
TIC	Technology in the Curriculum, United States
TTNS	The Times Network Systems, United Kingdom

BIBLIOGRAPHY

A Manual for Development of Educational Software (1985), Social Education Council, Ministry of Education, Tokyo, Japan.

Alberta Education (1982), "Evaluator's Guide for Microcomputer-Based Courseware", Alberta Department of Education, Canada.

Alberta Education (1983, 1984, 1985, 1986, 1987), "Computer Courseware Evaluations", Alberta Department of Education, Canada.

Alexander, K. and Blanchard, D. (1985), "Educational Software : A Creator's Handbook". Tecmedia, Loughborough, United Kingdom.

American Library Association (1979), "Guidelines for Using AACR2, Chapter 9 for Cataloguing Microcomputer Software", Chicago, United States.

Anderson, J. (1985), "Software Evaluation" in *Educational Software: A Creator's Handbook* (eds: Alexander K. and Blanchard D.). Tecmedia, Loughborough, United Kingdom.

Anderson, J. (1986), "The Search for Quality Australian Educational Software", in *Professional Computing*, Sydney, Australia, June.

ASCIS (1985), "Subject Heading List", Australian Schools Catalogue Information Service, Melbourne, Australia.

Avner, A. (1985), "Courseware Evaluation - or Devaluation?", in *Journal of Computer-Based Instruction*, Vol. 12, No. 1.

Barchechath, E. (1987), "Quelle Evaluation pour les Didacticiels ?", in *Annuaire 1987 des logiciels d'enseignement*, CESTA, France.

Becker, H.J. (1987), "Using Computers for Instruction", in *Byte*, February.

Bell, S., and Scott, I. (1985), "Springboards: Ideas for using computers in the classroom", Nelson, Sydney, Australia.

Bigum, C.; Bonser, S.; Evans, P.; Groundwater-Smith, S.; Grundy, S.; Kemmis, S.; McKenzie D.; McKinnon, D.; O'Connor, M.; Straton, R. and Willis, S. (1987), "Coming to Terms with Computers in Schools", Report of the Schools Studies of the National Evaluation Study of the Commonwealth Schools Commission's National Computer Education Program, Deakin Institute for Studies in Education, Australia.

Bitter, G.G. and Wighton, D. (1987), "The Most Important Criteria Used by the Educational Software Evaluation Consortium", in *The Computing Teacher*, Vol. 14, No. 6, March.

Blake, A. (1988), Private communication, Queensland Education Department, Australia.

Blemings, S. (1985), "Playing with Computers" in *Links*, No. 2, Queensland Education Department, Australia.

Blemings, S. (1987a), "Microcomputers in Queensland Pre-schools: An Investigation", in *Tomorrow's Technology Today*, Proceedings of Fifth Australian Computers in Education Conference, Adelaide, Australia.

Blemings, S. (1987b) "Computers and Preschool Children" in *Links*, No. 5.

Blemings, S. (1987c), "Can computers provide worthwhile learning experiences?", in *Links*, No. 6.

Blishen, E. (1969), *The School that I'd Like*, Penguin/Books, London, United Kingdom.

Bluhm, Harry P. (1987), "Computer-Managed Instruction: A Useful Tool for Educators?", in *Educational Technology*, January.

Bork, A. (1981), *Learning with Computers*, Digital Press, United States.

Bork, A. *et al.* (1980), *Computer Assisted Learning in Physics Education*, Pergamon Press, United Kingdom.

Bosler, U., (1988), Private communication, Institute for Science Education, Kiel, Germany.

Brophy, J. (1987), "Socializing student motivation to learn", in Maehr, M.L. and Kleiber, D.A. (Eds), *Advances in Motivation and Achievement*. Vol. 5, Greenwich, CT., United States.

Bruce, B. (1987), "Written Expression" in *Information Technologies and Basic Learning: Reading, Writing, Science and Mathematics*, OECD/CERI, Paris.

Bruce, B. and Rubin, A. (1984), *The Quill writing project for Alaska*, Final Report (BBN, Report No. 5789). Cambridge, MA: Bolt Beranek and Newman Inc., United Kingdom.

Burkhardt, H.; Fraser, R. *et al.* (1982), "Design and Development of Programs as Teaching Materials", Council for Educational Technology (CET), London, United Kingdom.

California Library Media Consortium "Courseware Reviews 1982", "Courseware Reviews 1983", "Courseware Reviews 1984", San Mateo Office of Education, California, United States.

California State Department of Education (1985), "Guidelines for Educational Software in California Schools", United States.

Cohen, R. (1987), *Les jeunes enfants - la découverte de l'écrit et l'ordinateur*, Presses Universitaires de France, Paris.

Council of Ministers of Education (1985a), *Software Evaluation: Criteria for educational computer software evaluation*, Canada.

Council of Ministers of Education (1985b), "Evaluation des Logiciels", Canada.

Council of Ministers of Education (1987), *Software Catalogue*, Canada.

De Landsheere, G. (1987), "Reading", in *Information Technologies and Basic Learning: Reading, Writing, Science and Mathematics*, OECD/CERI, Paris.

Dodd, S. (1982), "Cataloging Machine-Readable Data Files", American Library Association, Chicago, United States.

Dugdale, S. and Kibbey, D. (1980), "Prototype Microcomputer Courseware for Teaching High School Algebra", University of Illinois, Urbana-Champaign, United States.

Educational Software Evaluation Consortium (1986), "The 1986 Educational Software Preview Guide", International Council for Computers in Education (ICCE), Eugene, Oregon, United States.

Education and the Challenge of Technology (1986), Proceedings of Conference on Technology and Teacher Education, sponsored by the University of California, Berkeley and Apple Computer Inc.

Ely, D.P. (1987), "Education and Information Technology: What are the Questions?" in Flaxman, E., (ed.) *Trends and Issues in Education*, New York, United States.

England and Wales, Department of Education and Science (1987), *Aspects of the Work of the Microelectronics Education Programme, Report by HM Inspectors*, HMSO, London, United Kingdom.

Entwistle, N. (1987a), "Why Should Micros Make a Difference to Pedagogy?", paper presented at the SED-OECD Seminar on Microcomputers and Teacher Education, Glasgow, Scotland.

Entwistle, N. (1987b), *Understanding Classroom Learning*, Hodder and Stoughton, London, United Kingdom.

Entwistle, N.J. et Ramsden, P. (1983), *Understanding Student Learning*, Croom Helm, London, England.

EPIE Institute (1985, 1986, 1987), "TESS, The Educational Software Selector", The Educational Products Information Exchange, New York, United States.

Ewing, S. (1988), Private communication, Council of Ministers of Education, Canada.

Fitzgerald, D.; Hattie, J. and Hughes, P. (1985), *Computer Applications in Australian Classrooms*, Commonweath Department of Education, Australian Government Publishing Service, Canberra, Australia.

Gilbert, L.A. (1985), "The Distribution of Microcomputer Software to Education", Council for Educational Technology (CET), London, United Kingdom.

Goldenberg, E.P.; Russell, S.J.; Carter, C.J.; Stokes, S.; Sylvester, M.J.; Kelman, P. (1984), *Computers, Education and Special Needs*, Addison-Wesley, London, United Kingdom.

Gorman, M. and Winkler, P.W. (eds) (1979), "Anglo-American Cataloguing Rules", 2nd edition, American Library Association, Chicago, United States.

Griffin, J.A. (1988/4), "CAL innovation as viewed by purchasers of computer software in secondary schools", in *Journal of Computer Assisted Learning*, pp. 150-161.

Groundwater-Smith, S. (1987), "The Curriculum Implications", in Bigum *et al.*, *Coming to Terms with Computers in Schools*, Deakin Institute for Studies in Education, Australia.

Gwyn, R. (1986), in *New Information Technologies: A Challenge for Education*, OECD/CERI, Paris.

Hawkridge, D. (1984 and 1987), "Information Technology in Initial Teacher Training", Council for Educational Technology, London, United Kingdom.

Hawkridge, D., Vincent, T. and Hales, G. (1985), *New Information Technology in the Education of Disabled Children and Adults*, Croom Helm, London, United Kingdom.

Holznagel, D. (1988), Private communication, Microcomputer Software Information for Teachers (MicroSIFT), United States.

Howe, J. (1987), "Arithmetic and Mathematical Concepts" in *Information Technologies and Basic Learning: Reading, Writing, Science and Mathematics*, OECD/CERI, Paris.

ICCE (1983), "ICCE Policy Statement on Network and Multiple Machine Software", in *The Computing Teacher*, International Council for Computers in Education, Eugene, Oregon, United States, September.

ICCE (1987a), "ICCE Policy Statement on Code of Ethical Conduct for Computer-Using Educators", in *The Computing Teacher*, International Council for Computers in Education, Eugene, Oregon, United States, February.

ICCE (1987b), "ICCE Policy Statement on Criteria for Identification of Software Resource Centers", in *The Computing Teacher*, International Council for Computers in Education, Eugene, Oregon, United States, October.

Inoue, M. *et al.* (1987), "Utilization of New Information Technologies in Japanese Education Today" in *Educational Technology Research*, Educational Technology Journal Association of Japan, Vol. 10, Nos. 1/2, March.

Johnston, V.M. (1987), "The evaluation of microcomputer programs: an area of debate", in *Journal of Computer Assisted Learning*, United Kingdom, Vol. 3, No. 1.

Jolicoeur, K. and Berger, D.E. (1986), "Do We really Know What makes Educational Software Effective? A Call for Empirical Research on Effectiveness" in *Educational Technology*, United States, Vol. 26, No. 12.

Jones, N.B. (ed.) (1983), "Evaluation of Educational Software: A Guide to Guides", Northeast Regional Exchange, Chelmsford, MA., United States.

Kemmis, S. (1987), "How schools computing is changing education", in Bigum *et al.*, *Coming to Terms with Computers in Schools*, Deakin Institute for Studies in Education, Australia.

Kloosterman, P.; Ault, P.C. and Harty, H. (1987), "School-Based Computer Education: Practices and Trends", in *Educational Technology*, United States, Vol. 27, No. 4.

Klopfer, L.E. (1986), "Intelligent Tutoring Systems in Science Education: The coming generation of computer-based instructional programs", in *Journal of Computers in Mathematics and Science Teaching*, Vol. 5, No. 5.

Komoski, P.K. (1987), "Educational Microcomputer Software Evaluation: Its Challenge and its Uniqueness", in *Eurit 86, Developments in Educational Software and Courseware*, Pergamon Press, London, United Kingdom.

Kosmoski, P.K. (1988), Private communication, Educational Products Information Exchange Institute, United States.

Kulik, J.A.; Kulik, C.C. and Cohen, P.A. (1980), "Effectiveness of Computer-based College Teaching: A Meta-analysis of Findings", *Review of Educational Research*, No. 50.

Lafay, J.D. (1988), Private communication, CAMIF, France.

Lathrop, A. and Goodson, B. (1983), *Courseware in the Classroom*, Addison Wesley, Menlo Park, California, United States.

Lathrop, A. and Smith, V. (1986), "Preview Center Criteria: A Survey Summary" in *The Computing Teacher*, October.

Lathrop, A. (1988), Private communication, San Mateo Microcomputer Center, California, United States.

Leclercq, D. (1988), Private communication, University of Liège, Belgium.

Le Corre, Y. (1987), "Scientific and Technological Concepts" in *Information Technologies and Basic Learning: Reading, Writing, Science and Mathematics*, OECD/CERI, Paris.

Lesgold, A.M. (1987), "Main Issues and Future Prospects" in *Information Technologies and Basic Learning*, OECD/CERI, Paris.

Levin, J.A.; Bruta, M. J. and Vasconcellos, M.T. (1982), "Microcomputer-based environments for writing: a writer's assistant" in A.C. Wilkinson (ed.), *Classroom computers and cognitive science*, Academic Press, New York, United States.

Maehr, M.L. and Kleiber, D.A. (Eds), "Advances in Motivation and Achievement", Vol. 5, Greenwich CT, United Kingdom.

Malone, T.W. (1980a), "What makes things fun to learn: a study of intrinsically motivating computer games", unpublished PhD thesis, Department of Psychology, Stanford University, United States.

Malone, T.W. (1980b), "What makes computer games fun?", in *Byte*, December, pp. 258-277.

Marton, F.; Hounsell, D.J. and Entwistle, N.J. (1984), *The Experience of Learning*, Scottish Academic Press, Edinburgh, United Kingdom.

Mead Cheryl, L. (1983), "North Carolina: A Software Evaluation Plan with National Implications", in *Electronic Learning*, United States, October.

Microelectronics in Education Programme (MEP) (1982), "Guide to Evaluating Methods - A Manual for Microtechnology Innovation", Council for Educational Technology (CET), London, United Kingdom.

MicroSIFT (1983), "Evaluator's Guide for Microcomputer-Based Instructional Packages", ICCE, United States.

Ministère de l'Education nationale (1985a), "Catalogue des Logiciels", Paris.

Ministère de l'Education nationale (1985b), "Note sur les Applications pédagogiques de l'Informatique dans l'Enseignement secondaire", Paris.

Moursund, D. (1987), "A Growing Concern: Is 'Grass Roots' Dead?" in *The Computing Teacher*, October.

Nelissen, C. and Eisendrath, G. (1987), "Criteria for Educational Software", in *Eurit 86, Developments in Educational Software and Courseware*, Pergamon Press, London, United Kingdom.

New South Wales Department of Education (1985), "An Evaluator's Guide to Educational Software and Related Material", Australia.

New York State Education Department (1984), "Guide to Software Selection Resources: Part Four", United States.

New Zealand Department of Education (1988), "Computers in Education in New Zealand", paper given at the General Assembly and Seminar of the National Electronics Development Association, Delhi, India.

Nicolson, R.I. (1987), "A short-term plan for CAL", in *Journal of Computer Assisted Learning*, No. 3, pp. 81-88.

Nisbet, J.D. and Shucksmith, J. (1986), *Learning Strategies*, Routledge and Kegan Paul, London, United Kingdom.

OECD/CERI (1986), *New Information Technologies: A Challenge for Education*, Paris.

OECD/CERI (1987a), *Information Technologies and Basic Learning: Reading, Writing, Science and Mathematics*, Paris.

OECD/CERI (1987b), "The Introduction of Computers in Schools: The Norwegian Experience", Examiners' Report, Paris, (document for general distribution).

OECD/CERI (1987c), *Microcomputers and Secondary Teaching: Implications for Teacher Education*, ed. by the Scottish Education Department, Glasgow, United Kingdom.

OECD/CERI (forthcoming), *School Development and New Approaches to Learning: The Curriculum Redefined*, Paris.

Okey, J. and Oliver, R. (1986), "Using Computer Simulation to promote Achievement and Transfer", paper presented at the annual conference of the Australian Science Education Research Association.

Olds, H.F., Jr. (1983), "Evaluating the Evaluation Schemes", in Jones, N.B. (ed.), *Evaluation of Educational Software: A Guide to Guides*, Northeast Regional Exchange, Chelmsford, MA, United States.

OTA (1988), "Power On! New tools for Teaching and Learning", Congress of the United States Office of Technology Assessment.

Owston, R.D. (1987), *Software Evaluation: A Criterion-Based Approach*, Prentice-Hall, Scarborough, Ontario, Canada.

Pace, S. (1988), Private communication, Alberta Department of Education, Canada.

Papert, S. (1980), *Mindstorms: Children, Computers and Powerful Ideas*, Basic Books, New York, United States.

Pask, G. (1976/4-11), "Learning Styles and Strategies" in *British Journal of Educational Psychology*.

Platteeuw, E. (1988) Private communication, Ministry of Education, Belgium.

Poirot, J.; Taylor, R. and Powell, J. (1981), "Teacher Education" in *Topics: Computer Education for Elementary and Secondary Schools*, Association for Computing Machinery, New York, United States.

Poly, A. (1987), "The Production of Educational Software", in *Social Europe: Developments in the Introduction of New Information Technologies in Education*, Supplement 2/87, Commission of the European Communities, Belgium.

Pogrow, S. (1987), "Developing Higher Order Thinking Skills: The HOTS Program", in *The Computing Teacher*, August/September.

Preece, J. and Jones, A. (1985), "Training Teachers to Select Educational Computer Software: Results of a formative evaluation of an Open University pack", in *British Journal of Educational Technology*, January.

Rich, T. (1988), Private communication, Prince Edward Island Department of Education, Canada.

Rich, T. and Jafri, N. (1985), "Canadian Database for Educational Computer Software Information", unpublished paper, Canada.

Robinson, L. (1982), "The University-Industry Relationship", in *EDUCOM Bulletin*, Winter.

Rostron, A. and Sewell, D. (1984), *Microtechnology in Special Education*, Croom Helm, London, United Kingdom.

Roszak, T. (1986), *The Cult of Information*, Lutterworth Press, Cambridge, United Kingdom.

Rushby, N.J. (1979), *An Introduction to Educational Computing*, Croom Helm, London, United Kingdom.

Salvas, A.D. and Thomas, G.J. (1984), "Evaluation of Software", State Computer Education Centre, Melbourne, Australia.

Saunders, P. (1984), *Micros for Handicapped Users*, Helena Press, Whitby, United Kingdom.

Scardamalia, M.; Bereiter, C.; McLean, R.S.; Swallow, J. and Woodruff, E. (1987), "Computer supported intentional learning environment", paper presented at the Annual Meeting of the American Educational Research Association, Washington, United States, April.

Scottish Education Department (1986), *Learning and Teaching in the First Two Years of the Scottish Secondary School: A Report by HM Inspectors of Schools*", HMSO, Edinburgh, United Kingdom.

Scottish Education Department (1987), *Learning and Teaching in Scottish Secondary Schools: The Use of Microcomputers, HMSO, Edinburgh, United Kingdom.*

Scottish Education Department (1988), "Microcomputers and Secondary Teaching: Implications for Teacher Education", a Report on an International Seminar arranged by the Scottish Education Department in co-operation with the OECD, Paris.

SECTOR, (1982-84), "Special Education Computer Technology Online Resource – Courseware Evaluation Materials", Utah State University, United States.

Selmes, I. (1987), *Improving Study Skills*, Hodder and Stoughton, London, United Kingdom.

Shafroth, C. and Sakamoto, T. (1986), "A Comparison of Microcomputer Use in Japanese and U.S. Schools", in *Educational Technology Research*, Vol. 9, pp. 43-49.

Shute, V. (1987), "An Intelligent Tutoring System for Exploring Principles of Economics", University of Pittsburgh: Learning Research and Development Center, United States.

Smith, D. and Keep, R. (1986), "Children's opinions of educational software", in *Educational Research*, Vol. 28, No. 2.

Smith, S. (1987), "Has tomorrow's technology revolutionised classroom teaching?" in *Tomorrow's Technology Today*, Adelaide, Australia.

Stechner, B.M. and Solorzamo, R.S. (1987), "Characteristics of Effective Computer In-Service Programs", Educational Testing Service, Pasadena, California, United States.

Straton and Toussaint (1988), "The Commonwealth Computer Education Program in Non-Government Schools in Western Australia".

Tagg, W. (ed.) (1985), *A Parents' Guide to Educational Software*, Telegraph Publications, London, United Kingdom.

Taylor, D. (1988), Private communication, National Educational Resources Information Service, Bedfordshire, United Kingdom.

Taylor, R. (ed.) (1980), *The Computer in the School: Tutor, Tool, Tutee*, Teachers College Press, Columbia University, Oregon, United States.

Thompson, N. (1988), Private communication, National Council for Educational Technology, London, England.

Truett, C. and Ho, C. (1986), "Is Educational Software Field-tested?", in *The Computing Teacher*, Vol. 14, No. 2, October.

van Muylwijk, B. (1987), "What to do with Evaluation of Educational Software", in *Eurit 86. Developments in Educational Software and Courseware*, Pergamon Press, London, United Kingdom.

van Muylwijk, B. (1988), Private communication, Educational Computing Consortium, The Netherlands,

Willis, B.H. et *al*. (1986), "Interim Report on the Feasibility of and Progress in Developing a Model for a Software Evaluation Exchange Process", South East Educational Improvement Laboratory, North Carolina.

Winship., J.A. (1984), "The Review and Evaluation of Software", in *Dreams and Reality*. Proceedings of Second Australian Computer Education Conference, Sydney, Australia.

Winship., J.A. (1986), "National Software Clearinghouse Feasibility Study". Report to Australian Commonwealth Curriculum Development Centre, Perth, Australia.

Winship., J.A. (1987a), "Software Review or Evaluation – Are they both roses or is one a lemon?", in *Tomorrow's Technology Today*. Proceedings of Fifth Australian Computer Education Conference, Adelaide, Australia.

Winship., J.A. (1987b), "Constructing a Database of Software Information: The Schools Computing On-line Resources (SCOR) Database", in *Tomorrow's Technology Today. ibidem*.

WHERE TO OBTAIN OECD PUBLICATIONS
OÙ OBTENIR LES PUBLICATIONS DE L'OCDE

ARGENTINA – ARGENTINE
Carlos Hirsch S.R.L.,
Galería Guemes, Florida 165, 4° Piso,
1333 Buenos Aires
Tel. 30.7122, 331.1787 y 331.2391
Telegram: Hirsch-Baires

AUSTRALIA – AUSTRALIE
D.A. Book (Aust.) Pty. Ltd.
11-13 Station Street (P.O. Box 163)
Mitcham, Vic. 3132 Tel. (03) 873 4411
Telex: AA37911 DA BOOK Telefax: (03)873.5679

AUSTRIA – AUTRICHE
OECD Publications and Information Centre,
4 Simrockstrasse,
5300 Bonn (Germany) Tel. (0228) 21.60.45
Telex: 8 86300 Bonn Telefax: (0228)26.11.04
Gerold & Co., Graben 31, Wien 1 Tel. (1)533.50.14

BELGIUM – BELGIQUE
Jean de Lannoy, Avenue du Roi 202
B-1060 Bruxelles Tel. (02) 538.51.69/538.08.41
Telex: 63220

CANADA
Renouf Publishing Company Ltd.
1294 Algoma Road, Ottawa, Ont. K1B 3W8
Tel: (613) 741-4333
Telex: 053-4783 Telefax: (613)741.5439
Stores:
61 Sparks St., Ottawa, Ont. K1P 5R1
Tel: (613) 238-8985
211 rue Yonge St., Toronto, Ont. M5B 1M4
Tel: (416) 363-3171
Federal Publications Inc.,
165 University Avenue,
Toronto, ON M5H 3B9 Tel. (416)581-1552
Telefax: (416)581.1743
Les Publications Fédérales
1185 rue de l'Université
Montréal, PQ H3B 1R7 Tel.(514)954.1633
Les Éditions la Liberté Inc.,
3020 Chemin Sainte-Foy,
Sainte-Foy, P.Q. G1X 3V6, Tel. (418)658-3763
Telefax: (418)658.3763

DENMARK – DANEMARK
Munksgaard Export and Subscription Service
35, Nørre Søgade, P.O. Box 2148
DK-1016 København K Tel. (45 1)12.85.70
Telex: 19431 MUNKS DK Telefax: (45 1)12.93.87

FINLAND – FINLANDE
Akateeminen Kirjakauppa,
Keskuskatu 1, P.O. Box 128
00100 Helsinki Tel. (358 0)12141
Telex: 125080 Telefax: (358 0)121.4441

FRANCE
OCDE/OECD
Mail Orders/Commandes par correspondance :
2, rue André-Pascal,
75775 Paris Cedex 16 Tel. (1) 45.24.82.00
Bookshop/Librairie : 33, rue Octave-Feuillet
75016 Paris
Tel. (1) 45.24.81.67 or/ou (1) 45.24.81.81
Telex: 620 160 OCDE Telefax: (33-1)45.24.85.00
Librairie de l'Université,
12a, rue Nazareth,
13602 Aix-en-Provence Tel. 42.26.18.08

GERMANY – ALLEMAGNE
OECD Publications and Information Centre,
4 Simrockstrasse,
5300 Bonn Tel. (0228) 21.60.45
Telex: 8 86300 Bonn Telefax: (0228)26.11.04

GREECE – GRÈCE
Librairie Kauffmann,
28, rue du Stade, 105 64 Athens Tel. 322.21.60
Telex: 218187 LIKA Gr

HONG KONG
Government Information Services,
Publications (Sales) Office,
Information Services Department
No. 1, Battery Path, Central
Tel.(5)23.31.91 Telex: 802.61190

ICELAND – ISLANDE
Mál Mog Menning
Laugavegi 18, Pósthólf 392
121 Reykjavik Tel. 15199/24240

INDIA – INDE
Oxford Book and Stationery Co.,
Scindia House,
New Delhi 110001 Tel. 331.5896/5308
Telex: 31 61990 AM IN Telefax: (11) 332.5993
17 Park St., Calcutta 700016 Tel. 240832

INDONESIA – INDONÉSIE
Pdii-Lipi, P.O. Box 3065/JKT
Jakarta Tel. 583467
Telex: 73 45875

IRELAND – IRLANDE
TDC Publishers - Library Suppliers,
12 North Frederick Street,
Dublin 1 Tel. 744835-749677
Telex: 33530TDCP EI Telefax: 748416

ITALY – ITALIE
Libreria Commissionaria Sansoni,
Via Benedetto Fortini 120/10,
Casella Post. 552
50125 Firenze Tel. (055)645415
Telex: 570466 Telefax: (39.55)641257
Via Bartolini 29, 20155 Milano Tel. 365083
La diffusione delle pubblicazioni OCSE viene assicurata dalle principali librerie ed anche da :
Editrice e Libreria Herder,
Piazza Montecitorio 120, 00186 Roma
Tel. 6794628 Telex: NATEL I 621427
Libreria Hœpli,
Via Hœpli 5, 20121 Milano Tel. 865446
Telex: 31.33.95 Telefax: (39.2)805.2886
Libreria Scientifica
Dott. Lucio de Biasio "Aeiou"
Via Meravigli 16, 20123 Milano Tel. 807679
Telefax: 800175

JAPAN – JAPON
OECD Publications and Information Centre,
Landic Akasaka Building, 2-3-4 Akasaka,
Minato-ku, Tokyo 107 Tel. 586.2016
Telefax: (81.3) 584.7929

KOREA – CORÉE
Kyobo Book Centre Co. Ltd.
P.O.Box 1658, Kwang Hwa Moon
Seoul Tel. (REP) 730.78.91
Telefax: 735.0030

MALAYSIA/SINGAPORE – MALAISIE/SINGAPOUR
University of Malaya Co-operative Bookshop Ltd.,
P.O. Box 1127, Jalan Pantai Baru 59100
Kuala Lumpur, Malaysia/Malaisie
Tel. 756.5000/756.5425 Telefax: 757.3661
Information Publications Pte Ltd
Pei-Fu Industrial Building,
24 New Industrial Road No. 02-06
Singapore/Singapour 1953 Tel. 283.1786/283.1798
Telefax: 284.8875

NETHERLANDS – PAYS-BAS
SDU Uitgeverij
Christoffel Plantijnstraat 2
Postbus 20014
2500 EA's-Gravenhage Tel. (070)78.99.11
Voor bestellingen: Tel. (070)78.98.80
Telex: 32486 stdru Telefax: (070)47.63.51

NEW ZEALAND – NOUVELLE-ZÉLANDE
Government Printing Office Bookshops:
Auckland: Retail Bookshop, 25 Rutland Street,
Mail Orders, 85 Beach Road
Private Bag C.P.O.
Hamilton: Retail: Ward Street,
Mail Orders, P.O. Box 857
Wellington: Retail, Mulgrave Street, (Head Office)
Telex: COVPRNT NZ 31370 Telefax: (04)734943
Cubacade World Trade Centre,
Mail Orders, Private Bag
Christchurch: Retail, 159 Hereford Street,
Mail Orders, Private Bag
Dunedin: Retail, Princes Street,
Mail Orders, P.O. Box 1104

NORWAY – NORVÈGE
Narvesen Info Center - NIC,
Bertrand Narvesens vei 2,
P.O.B. 6125 Etterstad, 0602 Oslo 6
Tel. (02)67.83.10/(02)68.40.20
Telex: 79668 NIC N Telefax: (47 2)68.53.47

PAKISTAN
Mirza Book Agency
65 Shahrah Quaid-E-Azam, Lahore 3 Tel. 66839
Telegram: "Knowledge"

PORTUGAL
Livraria Portugal, Rua do Carmo 70-74,
1117 Lisboa Codex Tel. 347.49.82/3/4/5

SINGAPORE/MALAYSIA – SINGAPOUR/MALAISIE
See "Malaysia/Singapore". Voir «Malaisie/Singapour»

SPAIN – ESPAGNE
Mundi-Prensa Libros, S.A.,
Castelló 37, Apartado 1223,
Madrid-28001 Tel. 431.33.99
Telex: 49370 MPLI Telefax: 275.39.98
Libreria Bosch, Ronda Universidad 11,
Barcelona 7 Tel. 317.53.08/317.53.58

SWEDEN – SUÈDE
Fritzes Fackboksföretaget
Box 16356, S 103 27 STH,
Regeringsgatan 12,
DS Stockholm Tel. (08)23.89.00
Telex: 12387 Telefax: (08)20.50.21
Subscription Agency/Abonnements:
Wennergren-Williams AB,
Box 30004, S104 25 Stockholm Tel. (08)54.12.00
Telex: 19937 Telefax: (08)50.82.86

SWITZERLAND – SUISSE
OECD Publications and Information Centre,
4 Simrockstrasse,
5300 Bonn (Germany) Tel. (0228) 21.60.45
Telex: 8 86300 Bonn Telefax: (0228)26.11.04
Librairie Payot,
6 rue Grenus, 1211 Genève 11 Tel. (022)731.89.50
Telex: 28356
Maditec S.A.
Ch. des Palettes 4
1020 - Renens/Lausanne Tel. (021)635.08.65
Telefax: (021)635.07.80
United Nations Bookshop/Librairie des Nations-Unies
Palais des Nations, 1211 – Geneva 10
Tel. (022)734.60.11 (ext. 48.72)
Telex: 289696 (Attn: Sales) Telefax: (022)733.98.79

TAIWAN – FORMOSE
Good Faith Worldwide Int'l Co., Ltd.
9th floor, No. 118, Sec 2, Chung Hsiao E. Road
Taipei Tel. 391.7396/391.7397
Telefax: 394.9176

THAILAND – THAILANDE
Suksit Siam Co., Ltd., 1715 Rama IV Rd.,
Samyam, Bangkok 5 Tel. 2511630

TURKEY – TURQUIE
Kultur Yayinlari Is-Turk Ltd. Sti.
Ataturk Bulvari No. 191/Kat. 21
Kavaklidere/Ankara Tel. 25.07.60
Dolmabahce Cad. No. 29
Besiktas/Istanbul Tel. 160.71.88
Telex: 43482B

UNITED KINGDOM – ROYAUME-UNI
H.M. Stationery Office (01)873-8483
Postal orders only:
P.O.B. 276, London SW8 5DT
Telephone orders: (01) 873-9090, or
Personal callers:
49 High Holborn, London WC1V 6HB
Telex:297138 Telefax: 873.8463
Branches at: Belfast, Birmingham, Bristol, Edinburgh, Manchester

UNITED STATES – ÉTATS-UNIS
OECD Publications and Information Centre,
2001 L Street, N.W., Suite 700,
Washington, D.C. 20036-4095 Tel. (202)785.6323
Telex:440245 WASHINGTON D.C.
Telefax: (202)785.0350

VENEZUELA
Libreria del Este,
Avda F. Miranda 52, Aptdo. 60337,
Edificio Galipan, Caracas 106
Tel. 951.1705/951.2307/951.1297
Telegram: Libreste Caracas

YUGOSLAVIA – YOUGOSLAVIE
Jugoslovenska Knjiga, Knez Mihajlova 2,
P.O.B. 36, Beograd Tel. 621.992
Telex: 12466 jk bgd

Orders and inquiries from countries where Distributors have not yet been appointed should be sent to: OECD, Publications Service, 2, rue André-Pascal, 75775 PARIS CEDEX 16.

Les commandes provenant de pays où l'OCDE n'a pas encore désigné de distributeur devraient être adressées à : OCDE, Service des Publications, 2, rue André-Pascal, 75775 PARIS CEDEX 16.

72547-6-1989

OECD PUBLICATIONS, 2, rue André-Pascal, 75775 PARIS CEDEX 16 - No. 44915 1989
PRINTED IN FRANCE
(96 89 03 1) ISBN 92-64-13287-2

Rapid progress in information technology has led to the proliferation of educational software of heterogeneous types and quality. But choosing the software that can be integrated into the curriculum requires detailed information and reliable reviews and evaluations. This report analyses such mechanisms set up by educational agencies, discusses the main issues and stresses the necessity for government support and international co-operation in this area.